



March 10, 2006

Ms. Bonnie Rolandelli
Associate Engineering Geologist
Regional Water Quality Control Board, North Coast Region
5550 Skylane Boulevard, Suite A
Santa Rosa, CA 95403

Re: Interim Remedial Action Plan
Westport Community Store:
37001 North Highway One, Westport, Mendocino County, California
Clearwater Group Project No. ZB308H
Regional Water Quality Control Board Case No. 1TMC404
USTCF Claim No. 14259

Dear Ms. Rolandelli,

The Clearwater Group (Clearwater), on behalf of Mr. and Mrs. Eagleton, is pleased to present this Interim Remedial Action Plan (IRAP) prepared for the Westport Community Store located at 37001 North Highway One, Westport, Mendocino County, California (**Figure 1**) for your review, comments and direction.

SITE DESCRIPTION

The site is located on a sloping coastal shelf which grades westwards, and is approximately 80 feet above sea level. The Pacific Ocean shoreline lies 600 feet west of the project site. The project site is located on undifferentiated early Tertiary marine sediments; the immediate vicinity is underlain by clay-rich soils derived from the hills which rise sharply to the east. A seasonal, westward-flowing creek lies about ¼ mile south of the property, and Wages Creek, which also flows westward, lies about ¾ of a mile north of the property.



The town of Westport, with a population of about 50 people, has its own Community Water District, an agency which manages a potable water system, sewer system, and community fire department. Potable water for the area is supplied by Wages Creek, which lies about ½ mile to the north of the site. Water is pumped from the creek and filtered into a 100,000-gallon storage tank ¼ mile northeast of the town. Both Wages Creek and the water tank locations can be seen on Figure 1. High clay content in the local soils results in low percolation and high run off of surface waters. Occupants of the town used to get water from small domestic wells: one still sits in the back yard of the subject property. However, due to percolation and runoff effects, the local domestic wells became contaminated from septic field leachate waters. In response to this, in 1972, the State of California required the establishment of a Community Water District, and the town's water system was built in 1978.

INVESTIGATION BACKGROUND

The subject property is a combination residence, small community store and gas station. The gas station and community store have been in operation since the 1960s. One 1,000-gallon and one 550-gallon underground storage tank (UST) were removed from the property on November 20, 1998, and replaced with a 550 gallon above ground storage tank system. Soil and water samples collected during the excavation were shown by lab analyses to contain elevated concentrations of fuel hydrocarbons. In a letter dated February 16, 1999, the North Coast Regional Water Quality Control Board (NCRWQCB) requested that the spatial distribution of hydrocarbons in the subsurface be investigated.

Pursuant to the NCRWQCB's requests, Clearwater was retained, and installed, developed, and sampled three monitoring wells (MW-1, MW-2, and MW-3) at the subject location in July 1999 (**Figure 2**). As indicated in Clearwater's letter *Phase II Initial Subsurface Investigation, Well Installation, Groundwater Monitoring Report* (September 17, 1999), only one groundwater sample from the three monitoring wells, specifically from MW-1, contained detectable elevated



concentrations of any fuel additives, specifically methyl tertiary butyl ether (MTBE). No detectable concentrations of fuel hydrocarbons were found in any of the soil samples collected during well installation (**Table 1 and Table 2**).

In response to the results of this initial investigation, the NCRWQCB requested that the downgradient extent of the MTBE at the site be completely delineated (October 25, 1999). Clearwater was again retained, and installed two additional monitoring wells (MW-4 and MW-5) to the west and downgradient from the other three wells and the store in April, 2000, and afterwards completed four quarters of groundwater monitoring of all five site wells, as specified in its workplan, and approved by the NCRWQCB. In Clearwater's report *Additional Site Investigation* (May 8, 2000), and *Groundwater Monitoring Report, First Quarter 2001* (March 9, 2001), it was shown that no fuel hydrocarbons were detected in either of these new wells, and that MTBE at the site was limited to detection in MW-1.

Groundwater monitoring resumed, April of 2003, after verbal direction was received from the NCRWQCB to perform four quarters of groundwater monitoring. The NCRWQCB also renewed their request for the submittal of a Site Conceptual Model (SCM). Clearwater submitted a SCM for the subject property to the NCRWQCB in January of 2004. The Board's acceptance of the SCM was followed with a request for further site investigation focusing on the area in the immediate vicinity of the location of the former USTs and the dispenser area. The Board requested the additional work in order to help determine the status of the project. Clearwater submitted a *Workplan for Further Investigation* to the NCRWQCB on February 12, 2004. The workplan was approved by the NCRWQCB in their February 26, 2004 letter.

On August 3, 2004 Clearwater supervised the drilling of five soil borings using direct push technology. Fast-Tek Engineering Support Services (Fast-Tek) of Point Richmond, California (C-57 license number 624461) advanced soil borings B-1 through B-5 to approximately 20 feet bgs. The soil samples collected at the termination of each soil boring, approximately 20 feet bgs, were



retained for analysis for concentrations of total petroleum hydrocarbons as gasoline (TPHg), benzene, toluene, ethyl benzene and xylenes (BTEX), MTBE, tertiary butyl alcohol (TBA), tertiary amyl methyl ether (TAME), ethyl tertiary butyl ether (ETBE) and diisopropyl ether (DIPE) by EPA method 8260B. The samples were analyzed by Kiff Analytical LLC (Kiff), a California Department of Health Services certified laboratory located in Davis, California. A grab ground water sample was also collected at the termination of each soil boring and submitted for the same analytical suite. Clearwater summarized the findings in a report, *Results of Additional Investigation*, dated September 24, 2004, concluding that the tight clay formation observed while drilling indicated a relatively low K value (hydraulic conductivity) while the high TPHg to benzene ratio indicated the presence of weathered gasoline. The concentration of TPHg reported for the grab groundwater samples ranged in value from 1,400 µg/L (B-2) to 150 µg/L. Benzene was reported in only two of the grab groundwater samples B-3 (4.9 µg/L) and B-4 (8.10 µg/L). The concentration of MTBE reported in the samples collected from B-1 through B-4 ranged in value from 13 µg/L (B-2) to 130 µg/L (B-3) (**Table 2**).

During the first quarter groundwater monitoring event conducted on February 18, 2005, Clearwater personnel discovered that the well casing of MW-3 was damaged and a water sample could not be collected at that time. The cause of the damage is unknown. Due to the current curve of the pipe, a standard 2-inch diameter bailer does not descend past a depth of 2-feet bgs. Clearwater personnel succeeded in sampling monitoring well MW-3 with a 0.5-inch diameter disposable polyethylene bailer due to the damaged well casing. The samples collected from the well are considered to be grab samples due to minimal water movement achieved when using a small diameter bailer.

In response to the request for site closure made in the *Groundwater Monitoring Report, Second Quarter 2005* prepared by Clearwater, the NCRWQCB per their June 27, 2005 letter adjusted the groundwater monitoring program instead of granting site closure. The NCRWQCB did not concur with the recommendation for site closure due to the presence of MTBE in MW-1. The



groundwater monitoring program has been reduced from a quarterly to semi-annual basis. In addition since their installation, petroleum related hydrocarbons have not been detected in groundwater monitoring wells MW-2, MW-4 and MW-5 and therefore they are to be used for groundwater gradient and direction purposes only. The NCRWQCB also requested that MW-3 be repaired.

Clearwater began to plan for the repair of MW-3; however, when the high cost to repair the well was established, Clearwater contacted the NCRWQCB to discuss the proposal. During telephone and email correspondence between Clearwater and NCRWQCB personnel it was determined that MW-3 did not need to be repaired unless additional subsurface investigation was to be conducted onsite.

INTERIM REMEDIAL ACTION PLAN

Purpose of Interim Remedial Action Plan

The NCRWQCB in their December 21, 2005 letter (**Attachment A**) concurred with the recommendations made in the *Monitoring Report, Third Quarter 2005* prepared by Clearwater dated December 7, 2005. The report recommended that an interim remedial action plan be prepared to address the presence of MTBE detected in the groundwater samples collected from monitoring well MW-1 and MW-3. There are a many factors which need to be considered when choosing the appropriate remediation method for a project location. Besides choosing a method which will remediate the current level of contamination to acceptable closure levels, the method must also be conducive to site conditions.

As previously stated the project site is underlain by a tight clay formation which indicates a relatively low K value. This along with the poor absorption rate of MTBE by activated carbon means that groundwater extraction and treatment would not be an appropriate remediation technology employed at the project site. Soil vapor extraction and treatment has been shown to be



successful in remediating concentrations of MTBE in other project locations. However the tight clay formation would most likely result in low recovery rates. Soil vapor extraction systems tend to be loud and cumbersome and since there are numerous residential homes within the immediate vicinity of the project location, a soil vapor extraction system is not recommended. In situ treatment of the hydrocarbon plume would be ideal for this project location.

Within tight clay formations, in situ treatment can be accomplished through chemical oxidation (ozone sparging) or enhanced bio-remediation using a mass transfer tool (iSOCs). Though both methods will be discussed in this text, the later is more preferable due to the passive nature of the delivery system.

PROPOSED REMEDIATION METHODS

Chemical Oxidation (Ozone Sparging)

In order to address the remaining onsite contamination, chemical oxidation through the use of ozone sparging may be considered. Ozone gas (O_3) can oxidize contaminants directly or through the formation of hydroxyl radicals. Ozone has proven to be effective in destroying a wide variety of organic chemicals including MTBE. Ozone destroys organic chemicals through the process of chemical oxidation, during which the targeted organic chemical is broken down into carbon dioxide and water. Like hydrogen peroxide (H_2O_2), ozone reactions are most effective in aqueous systems with acidic pH. The half-life of ozone in an aqueous system with a pH of 6.0 is approximately 20 minutes. The rate of ozone decomposition increases as the level of pH becomes more basic. At a pH of 7.0 the half-life of ozone is approximately 15 minutes, while at a pH of 8.0 the half-life of ozone is reduced to approximately 5 minutes. Ozone delivery technology is available in skid mounted units in which the ozone is produced onsite. Ozone would require closely spaced delivery points (e.g., air sparging wells).

CLEARWATER

Environmental Services

In addition to the chemical oxidation of hydrocarbons by ozone, in situ decomposition of the ozone in groundwater can lead to beneficial oxygenation and bio-stimulation. Ozone is one of the strongest oxidants available for the treatment of aqueous solutions and gaseous mixtures. Ozone is sufficiently soluble in water and reactive so that its oxidation properties can be fully used. In treating potable water, wastewater, and landfill leachate, ozone has the proven ability to convert organic materials to biodegradable compounds. The standard method for applying ozone as a petroleum hydrocarbon remediation technology is as follows.

Ozone is diffused into groundwater under an injection line pressure of about 15 psi. Microbubbles of ozone are created using an ozone resistant ceramic diffusion tool. The ozone contained within the bubbles diffused into groundwater reacts extremely rapidly to chemically decompose the organic chemicals into simple products (alcohols, acetate and formate). The residual oxygen from the reaction is available for bacterial bioremediation activity; the bacteria then consume the breakdown products and convert them to carbon dioxide and water. The reaction is produced with very low ozone concentrations (molar ratios) compared to volatile organic compounds (VOC) concentrations in the groundwater. Ozone has a half-life of 20 minutes in water and a radius of influence of 5 to 10 feet depending on a variety of factors. The rate of contaminant destruction is dependant on ozone concentration, pressure, temperature, iron content and other factors.

This technology has many advantages over other active remedial approaches including a relatively low capital equipment cost, minimal site disturbance and self-contained equipment. Due to its reactivity, ozone has the potential to substantially decrease the mass and concentration of contaminants in a short period of time. Vapor controls are not necessary since the contaminants are destroyed rather than transferred from one phase to another. There are a number of case studies available where ozone was used to remediate MTBE impacted groundwater. See **Attachment B** for ozone technology specific information and case studies.



The disadvantage of using ozone technology at the project site is that; 1) the ozone generator requires an electric power source and 2) a sound enclosure may be required for noise reduction in order to accommodate the nearby residents thus increasing the overall cost of the system. Prior to implementing the ozone sparging system a bench test and pilot study should be conducted to evaluate its use at the project site.

Enhanced Bioremediation Using a Mass Transfer Tool

Enhanced bioremediation using supplied dissolved oxygen has been proven to be an effective technology for the degradation of dissolved and sorbed-phase hydrocarbons via bacteriological activity. However, many groundwater environments that are high in ferrous iron and biological oxygen demand (BOD), for example, will consume large volumes of injected dissolved oxygen before aerobic bacteria can use the oxygen as part of the process of hydrocarbon degradation. Thus, delivery of dissolved oxygen at sufficient concentrations and volume is essential to off-set potential chemical and biological oxygen demand.

A growing number of remediation contractors (500 sites worldwide) are using a Canadian technology called in-situ Submerged Oxygen Curtain (iSOC), which infuses oxygen gas in the dissolved phase (using a spargeless technique) into groundwater. The proprietary structured polymer used in the iSOC unit provides a large surface area for gas transfer, and is housed within a 15 inch by 1.75 inch stainless steel casing. The device is placed down a 2 or 4-inch monitor well and is connected to a regulated supply of industrial grade compressed oxygen, which is stored inside a secured steel cylinder. The rate of oxygen infusion is typically in the range of 15 to 20 cubic centimeters per minute. Resultant dissolved oxygen (DO) concentrations in the iSOC wells range from as high as 40 to 55 mg/L (with 5-10 vertical feet of water in the well). The effective radius of influence of a typical injection well equipped with iSOC is 10 to 15 feet (horizontal). In optimal conditions, 3.2 lbs of oxygen are required to treat 1 lb of hydrocarbon contaminant. See **Attachment C** for iSOC technology specific information and case studies. Oxygen enrichment is achieved without causing aeration or volatilization of organic compounds. The process of oxygen



transfer into the aquifer is gas diffusion not sparging. The technology requires no external power sources, generates no noise, vibrations, or remediation wastes, and is installed with minimal disruptions to the site. Maintenance includes periodic exchange of oxygen cylinders and monthly operations and maintenance visits to ensure proper gas pressure and delivery through out the system. Continuous groundwater sampling is required after installation of system components.

For iSOC evaluation, additional testing for indigenous microbes, biologic parameters, and nutrient levels is needed to determine if the use of oxygen will work given the subsurface parameters on this site; it will also address whether additional microbes and/or nutrients need to be added to the subsurface to change the conditions so that the oxygen does work.

Bioremediation Parameter Bench Testing

Clearwater proposes to conduct a feasibility test by collecting bioremediation parameters including dissolved alkalinity, nitrate, ferrous iron, and sulfate, as well as down-hole measurement of dissolved oxygen (DO) and reduction-oxidation potential (ORP). These must be measured to establish a baseline of the environmental conditions of the subsurface and the potential of the site for augmented bioremediation. Each enhanced bioremediation feasibility test sample includes the contaminants, as well as nitrate and sulfate, macronutrients, orthophosphate-phosphate and ammonia as nitrogen. To evaluate the oxygen demand in groundwater sample tests include the five-day biological oxygen demand (BOD₅) and chemical oxygen demand (COD). Additional analyses include total organic carbon, total inorganic carbon, total dissolved solids and alkalinity (speciated). Total heterotrophic count and specific hydrocarbon degraders will be performed. The summary of the analytical test requirements are:

FIELD MEASUREMENTS

Dissolved Oxygen (DO) (downhole meter)
Oxidation-Reduction Potential (ORP) (downhole meter)
Temperature, pH, conductivity (field meter)
Ferrous iron (Fe⁺²) and Total iron (field kits)



LABORATORY MEASUREMENTS

Direct Indicator

Contaminant

Analyses

TPHg, BTEX, MTBE, TBA, etc.

Indirect Indicators

Microbial Activity

Analyses

Total Heterotrophic Plate Count
Specific Hydrocarbon Degraders

Macronutrients

Ammonia as nitrogen
Ortho-phosphate

Terminal Electron Acceptors

Oxygen, measured as dissolved oxygen (DO) in field
Nitrate (lab analysis)
Ferrous iron (Fe^{+2}) and Total iron (field kits)
Sulfate (lab analysis)

Total Oxygen Demand

Chemical Oxygen Demand (COD, lab)
Biological Oxygen Demand (BOD_5 , lab)

Carbon Status

Total organic carbon (TOC, lab)
Total inorganic carbon (TIC, lab)
Speciated Alkalinity (lab)

Other Analyses

Total dissolved solids (TDS, lab)

Laboratory testing offers insight into site-specific conditions in a controlled laboratory setting. Clearwater recommends that water samples from MW-1 (plume core), MW-3 (up gradient location) and MW-4 (down gradient) be submitted to the laboratory for testing. CytoCulture Environmental Biotechnology located in Pt. Richmond, California, will analyze the samples for aerobic total heterotrophic plate count and specific hydrocarbon degraders. Alpha Analytical Laboratories, Inc. located in Ukiah, California will analyze samples for carbon status, total oxygen demand, terminal electron acceptors and macronutrients. Once the baseline parameters are established, Clearwater proposes to install four iSOC treatment wells and an additional groundwater monitoring well (MW-6) within the vicinity of the core of the plume (**Figure 3**).



Proposed iSOC System and Additional Monitoring Well Locations

The concentration of MTBE reported in the grab water samples collected during the August 3, 2004 subsurface investigation indicate that the hydrocarbon plume sourcing from the former UST extends horizontally from Abalone Street north towards MW-1. The highest concentration of MTBE reported during the subsurface investigation event was 130 µg/L detected in the sample collected from soil boring B-3. Therefore Clearwater recommends that an additional groundwater monitoring well be installed within the immediate vicinity of soil boring B-3 to monitor the southern edge of the hydrocarbon plume.

As previously stated the tight clay formation observed during the subsurface investigation event suggests a relatively low hydraulic conductivity which is supported by the shallow groundwater gradient observed during quarterly groundwater monitoring events. To maximize treatment of the hydrocarbon plume through enhance bioremediation Clearwater proposes that at least four iSOC oxygen infusion wells be installed at the project site. The proposed locations of the iSOC wells (IW-1 through IW-4) are such that the minimum effective radius of influence would overlap, maximizing the treatment of the hydrocarbon plume (**Figure 4**).

Proposed iSOC System Well Installation Activities

Prior to conducting field activities, appropriate well installation permits for drilling will be obtained from the Mendocino County Health Department. Due to the proposed system and monitoring well installation locations within the public right of way along Highway One, an encroachment permit from the California Department of Transportation (CALTRANS) will be required. As a condition of the encroachment permit, a performance bond may be required by CALTRANS. All field personnel on-site will review and sign the site Health and Safety plan, prepared in accordance with OSHA 1910.120, at the start of each field day. The site specific Health and Safety Plan will be updated as needed to include hazards associated with well installation and handling of compressed gas cylinders. Once the appropriate permits have been received and the drilling date scheduled, the proposed iSOC well locations will be marked in



white marker paint and Underground Service Alert (USA) will be requested to identify utilities leading to the site. All fieldwork will be conducted in accordance with Clearwater's Field Procedures (**Attachment D**).

Under supervision of a Clearwater geologist, a C-57 licensed drilling contractor will advance each soil boring using a hollow stem auger mounted drill rig. The soil borings will be 8 inches in diameter and be advanced deep enough so to encounter groundwater, though it is expected that they will not be drilled deeper than approximately 20 feet bgs. Soil samples will be collected at five-foot depth intervals and retained for laboratory analysis. Portions of each soil sample will also be retained for visual classification according to the Unified Soil Classification System. Soil samples will be screened for the presence of volatile hydrocarbons using a photo-ionization detector (PID). Additional soil samples will be collected at elevated PID readings or where visual observations suggest the presence of petroleum related hydrocarbons. Soil samples will be collected using EPA Method 5035 and submitted to Kiff Analytical LLC, a California Department of Health certified laboratory located in Davis, California, for analysis. The soil samples will be analyzed for concentrations of TPHg, BTEX, MTBE, TBA, ETBE, DIPE, TAME, 1,2-Dichloroethane (1,2-DCA) and 1,2-Dibromoethane (EDB) using EPA Method 8260B. Additionally, a groundwater sample will be taken from the borehole, using a disposable or clean stainless steel bailer and submitted for the same analysis as the soil samples.

The Clearwater geologist will then supervise the construction of the proposed iSOC system wells by the C-57 licensed drilling contractor. The iSOC wells will be constructed of 2 inch diameter schedule 40 polyvinyl chloride (PVC) casing with 0.01 slot well screen extending from the bottom of the boring to approximately 5 feet below ground surface. The remaining 5 feet will be constructed of 2 inch pvc blank. A filter pack typically consisting of #3 Lonestar sand or the equivalent will be placed from the bottom of the boring to approximately 2 feet above the top of the well screen. A 2 foot thick seal of hydrated bentonite chips will be installed immediately above the filter pack. Cement slurry will fill the remaining annular space and a traffic grade well vault



will be installed flush with the ground's surface (**Figure 5**). Clearwater will survey the top of casing elevations relative to mean sea level using a permanent benchmark as a reference point, accurate to within ± 0.01 -feet. The soil cuttings will be placed in Department of Transportation (DOT) approved 55-gallon drums and transported to the Clearwater equipment yard in Pt. Richmond, California pending analytical results and disposal at an approved disposal facility. Rinseate water generated during decontamination of the hollow stem augers will be collected into a 250-gallon portable holding tank and transported to the Clearwater equipment yard. At the yard the investigation derived waste will then be transferred to 55-gallon drums pending the analytical results. The rinseate water will then be transported to Instrat Inc. located in Rio Vista, California for disposal.

iSOC Well Survey and Development

The new iSOC system wells will be developed within two weeks following their installation prior to the installation of the iSOC system. An electronic water level indicator, accurate to within ± 0.01 -foot, will be used to gauge depth to water. The wells will be checked for the presence of separate-phase hydrocarbons (SPH) prior to development. The grab water samples collected during the installation activities will be used to determine the baseline hydrocarbon concentrations within these wells, therefore additional groundwater samples will not be required.

The iSOC wells will be developed by surging and bailing. Development will involve the removal of water from each well until such time that it is relatively free of sediment, and pH, temperature, and conductivity parameters have stabilized. It is anticipated that the water volume removed will not exceed ten saturated casing volumes. Groundwater monitoring and well purging information will be recorded on Gauge Data/Purge Calculations and Purge Data sheets.

Purging devices will be decontaminated between wells in an Alconox® wash followed by double rinse in clean tap water to prevent cross-contamination. Purge and rinseate water will be collected into a 250-gallon portable holding tank and transported to the Clearwater equipment



yard in Point Richmond, CA. At the yard the investigation derived waste will then be transferred in to 55-gallon drums pending disposal at Instrat Inc.

iSOC SYSTEM INSTALLATION

Equipment Requirements

Clearwater recommends that the iSOC system wells be equipped with individual gas delivery systems installed within a 24-inch by 24-inch traffic grade well vault (**Figure 6**). The individual iSOC systems would operate independently of each other ensuring continual treatment of the hydrocarbon plume if for some reason one system experiences a malfunction. The remediation system will be connected from the probe in the infusion well location to 1/4-inch outer diameter (OD) flexible polyurethane tubing laid securely within the well vault. Each individual infusion well will be attached to a valve to regulate the air flow. The individual delivery systems will be supplied oxygen from a 124 cubic foot gas-phase aluminum cylinder. It is recommended that the gas cylinders be housed vertically within the well vault. The cylinders are approximately 42 inches long and have an 8 inch diameter, therefore Clearwater recommends that a 10 inch diameter hole be dug to approximately 40 inches bgs to hold the gas cylinder. The hole will then be lined with a 10-inch by 40-inch pvc or metal pipe. The cylinders will also be equipped with pressure gauges to monitor the available oxygen supply. In addition, a dual stage low flow (0-125 psi) pressure regulator (Victor 270 or equivalent) and a low air flow meter should be used. The appropriate air flow meter is a Cole Parmer Model P-03217. Miscellaneous fittings and supplies are available from Global Technologies Inc. Compressed air cylinders can be obtained from local welding supply shops, such as Airgas.

Following installation of the iSOC system, startup monitoring of the system will consist of the following parameters; groundwater pH, temperature, conductivity DO, ORP, ferrous iron and total iron concentrations in the infusion wells and MW-1. The groundwater parameters will be monitored downhole and oxygen tank pressures recorded according to the following schedule:

- The day of installation
- Two weeks from the date of installation
- Four weeks from the date of installation
- Eight weeks from date of installation

iSOC system monitoring will then be performed on a monthly basis. Clearwater recommends that the groundwater monitoring program return to a quarterly schedule from the semi-annual schedule currently required.

After concentrations decline to levels amenable to remediation by natural -attenuation, without the aide of enhanced oxygen infusion, the gas cylinders will be disconnected. The probes will be removed from the infusion wells and quarterly monitoring will continue at the site until site closure can be considered. As a precaution, the individual iSOC system vaults will remain in place until site closure is granted. This will allow for the return use of oxygen infusion if for some reason the concentrations of petroleum related hydrocarbons spike during a quarterly monitoring event.

Proposed Schedule and Reporting

Clearwater recommends that the enhanced bioremediation feasibility study be conducted concurrently with the next groundwater monitoring event scheduled once approval has been received from the NCRWQCB to proceed. A groundwater monitoring report which includes the results of the feasibility study will be prepared and submitted to the NCRWQCB. The groundwater moinitoring report will include either a recommendation for the installation of the iSOC system as described in this text (with or without nutrient modification) or a recommendation to procede with an applicable ozone bench study and pilot test. A schedule of activities associated with the the proposed iSOC system installation or the additional ozone



studies will be included in the groundwater monitoring report for the review, comments and direction from the NCRWQCB.



Certification

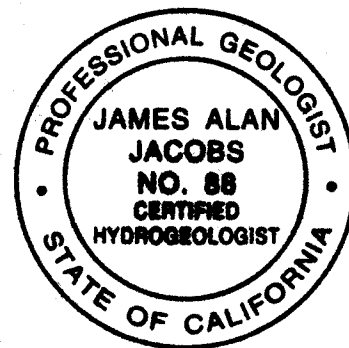
This report was prepared under the supervision of a Professional Geologist in the State of California. All statements, conclusions and recommendations are based solely upon published results from previous consultants, field observations by Clearwater Group, Inc. and laboratory analysis performed by a California DHS-certified laboratory related to the work performed by Clearwater Group, Inc.

Information and interpretation presented herein are for the sole use of the client and regulating agency. The information and interpretation contained in this document should not be relied upon by a third party.

The service performed by Clearwater Group, Inc. has been conducted in a manner consistent with the level of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions in the area of the site. No other warranty, expressed or implied, is made.

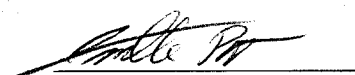
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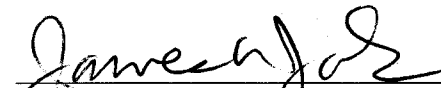
CLEARWATER GROUP



Prepared by:

Reviewed by:

for 
Jessica Chiaro-Moreno
Project Manager


James A. Jacobs, P.G. #4815, C.H.G. #88
Chief Hydrogeologist

cc Mr. Charles W. Eagleton, 16499 Crescent Court, Middletown, California, 95461



FIGURES:

- Figure 1: Site Location Map**
- Figure 2: Site Plan**
- Figure 3: Proposed iSOC System and Monitoring Well Locations**
- Figure 4: Proposed iSOC System and Monitoring Well Locations with Radius of Influence**
- Figure 5: Proposed iSOC System Well Construction Detail**
- Figure 6: Proposed iSOC System Design**

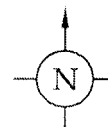
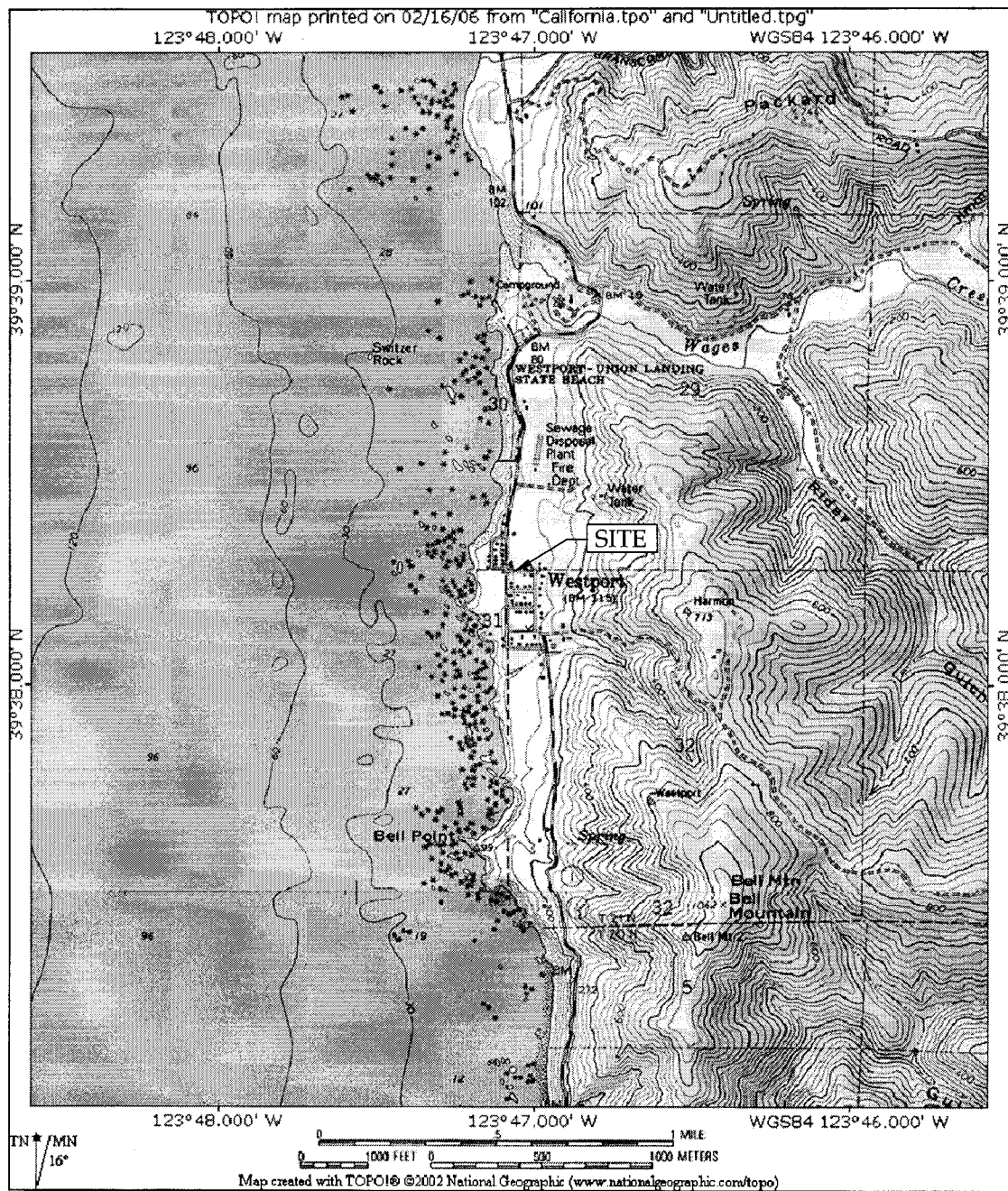
TABLES

- Table 1: Groundwater Monitoring Well Construction Detail**
- Table 2: Soil Analytical Results**
- Table 3: Groundwater Elevations and Analytical Results**

ATTACHMENTS:

- Attachment A: December 21, 2005 NCRWQCB Letter**
- Attachment B: Ozone Technology Specific Information and Case Studies**
- Attachment C: iSOC Technology Specific Information and Case Studies**
- Attachment D: Clearwater Group Field Protocols**

FIGURES



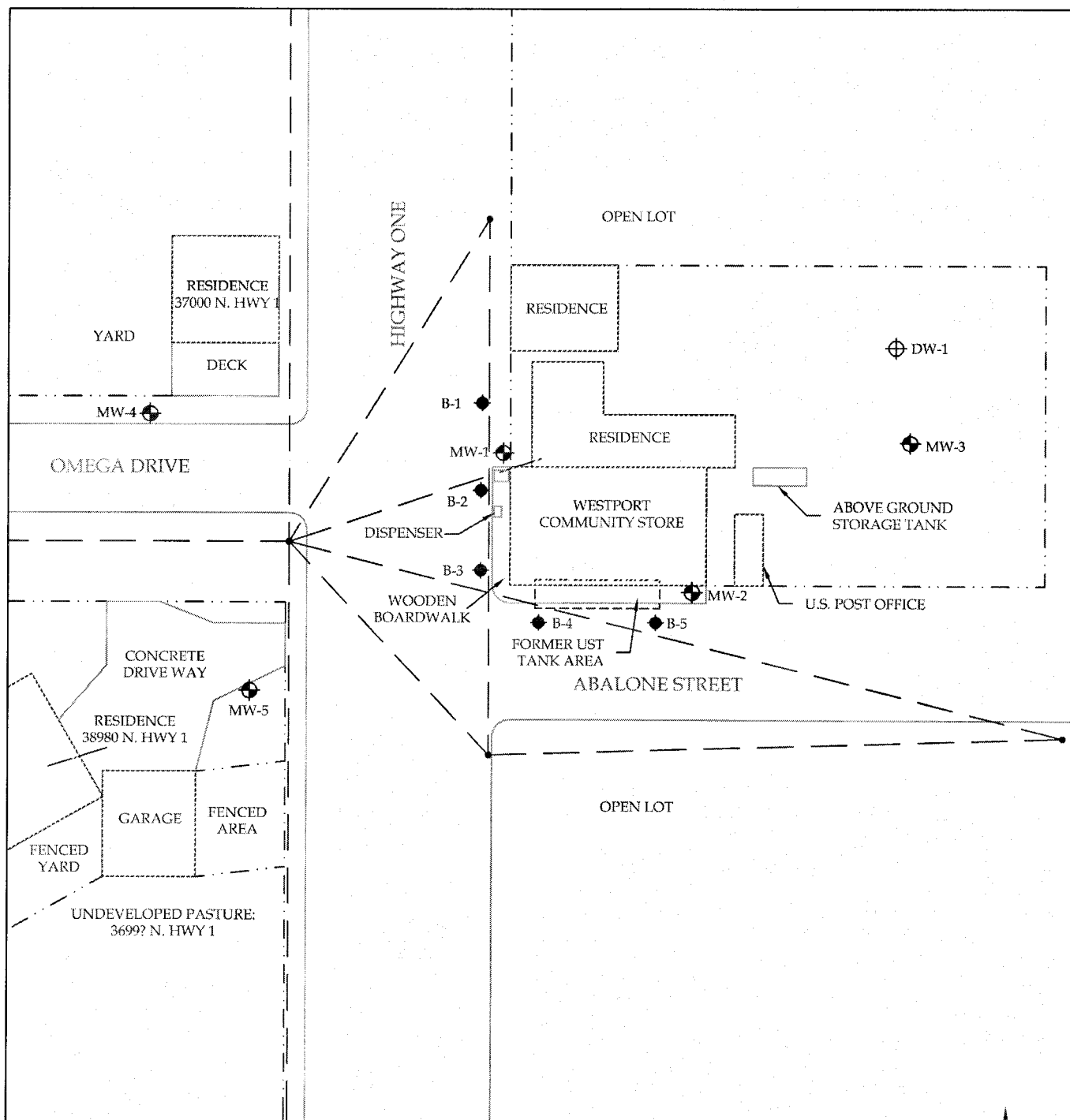
SITE LOCATION MAP
 Westport Community Store
 37001 North Highway 1
 Westport, California

CLEARWATER GROUP

Project No.
ZB308H

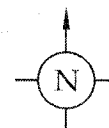
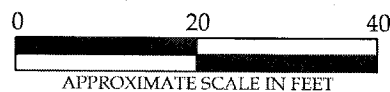
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Figure
1



LEGEND

---	PROPERTY LINE	◆ MW-1	MONITORING WELL
---	ELECTRICAL & TELEPHONE LINES	⊕ DW	DOMESTIC WATER WELL
•	ELECTRICAL POLE	◆ B-4	BORING LOCATION



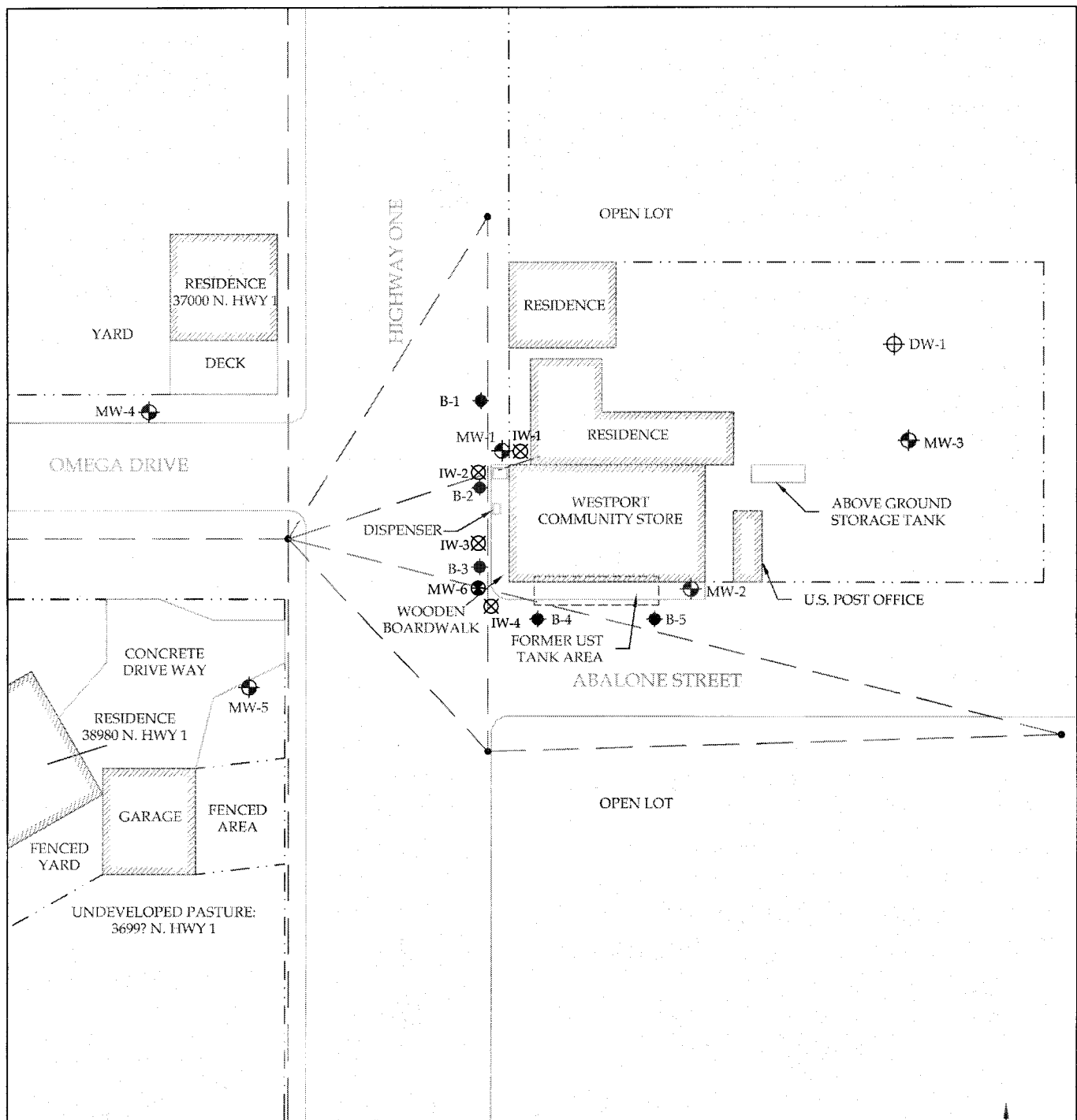
SITE PLAN
Westport Community Store
37001 North Highway 1
Westport, California

CLEARWATER GROUP

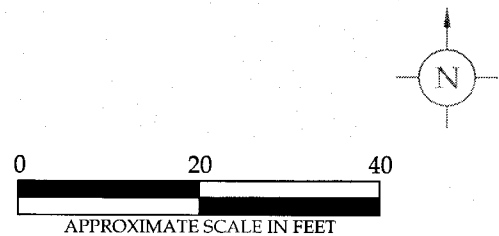
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Figure
2

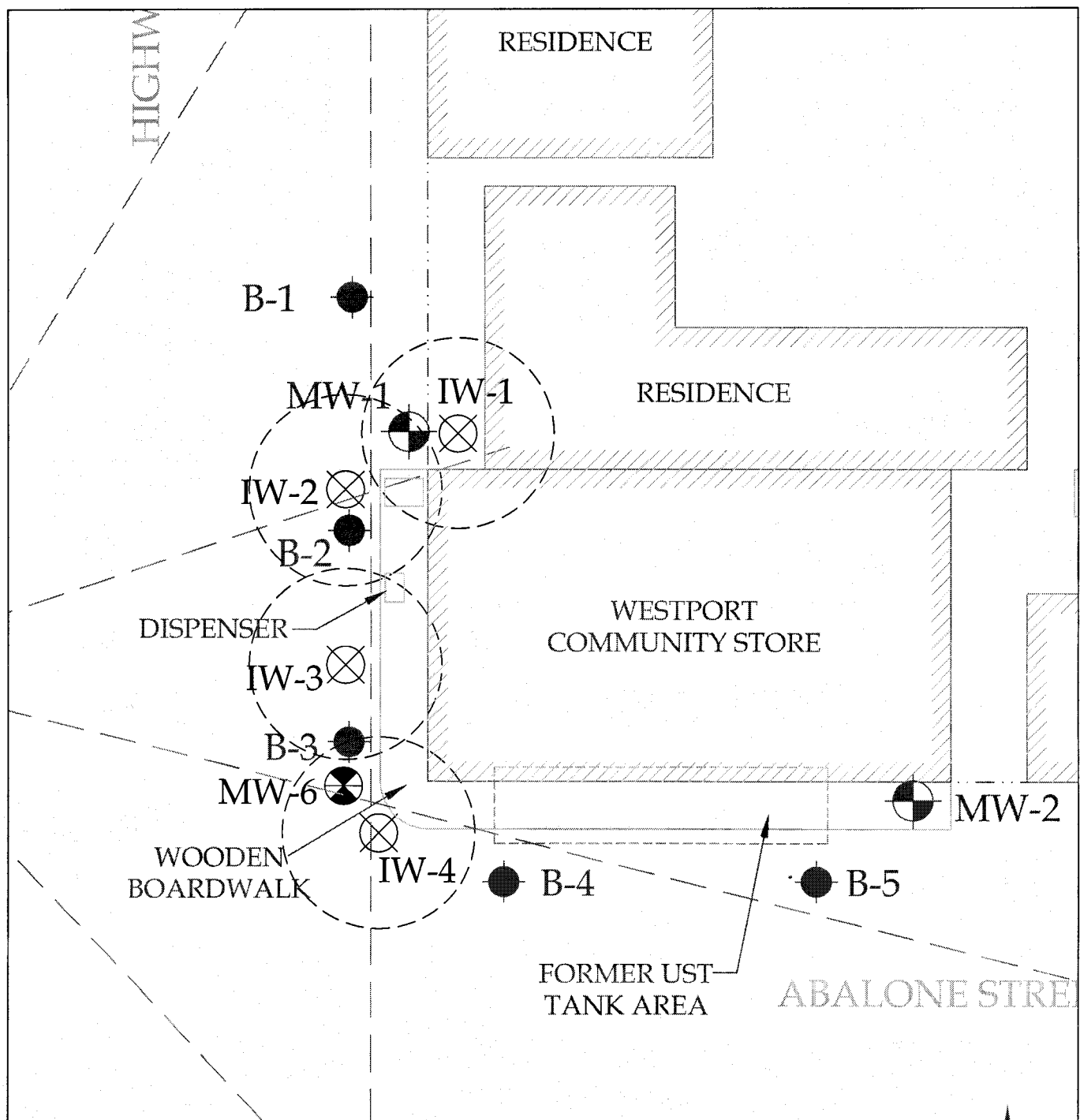


LEGEND	
---	PROPERTY LINE
---	ELECTRICAL & TELEPHONE LINES
•	ELECTRICAL POLE
◆ B-4	BORING LOCATION
⊕ MW-1	MONITORING WELL
⊕ DW	DOMESTIC WATER WELL
⊕ MW-6	PROPOSED MONITORING WELL LOCATION
⊗ IW-1	PROPOSED iSOC WELL LOCATION

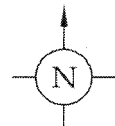
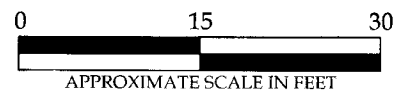


Proposed iSOC and Monitoring Well Locations	CLEARWATER GROUP		
	Project No. ZB308H	Figure Date 3/06	Figure 3

Westport Community Store
37001 North Highway 1
Westport, California



LEGEND	
---	PROPERTY LINE
- - -	ELECTRICAL & TELEPHONE LINES
•	ELECTRICAL POLE
◆	B-4 BORING LOCATION
⊕	MW-1 MONITORING WELL
⊗	DW DOMESTIC WATER WELL
⊙	MW-6 PROPOSED MONITORING WELL LOCATION
⊗	IW-1 PROPOSED iSOC WELL LOCATION



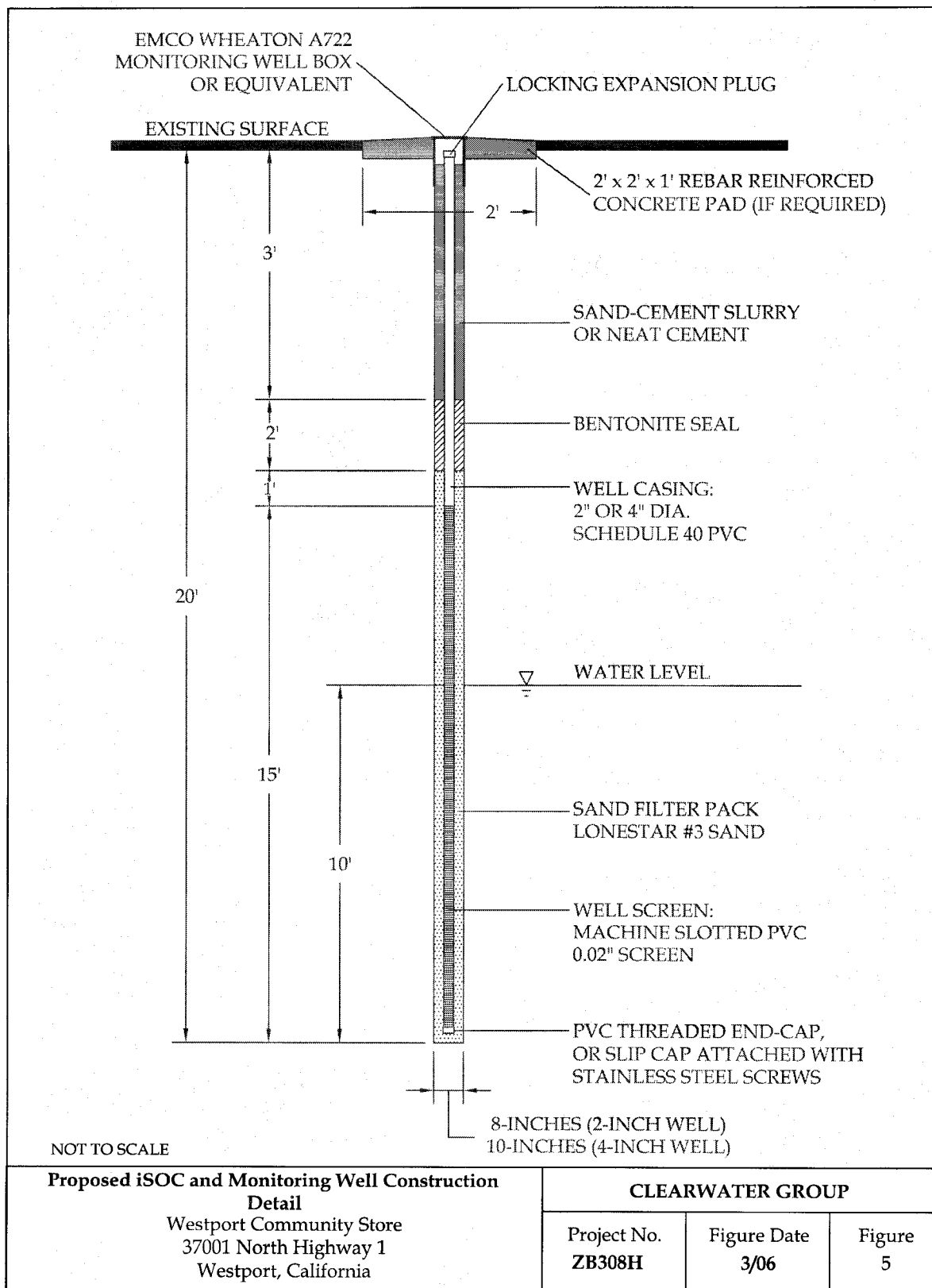
Proposed iSOC and Monitoring Well Locations with iSOC Radius of Influence
 Westport Community Store
 37001 North Highway 1
 Westport, California

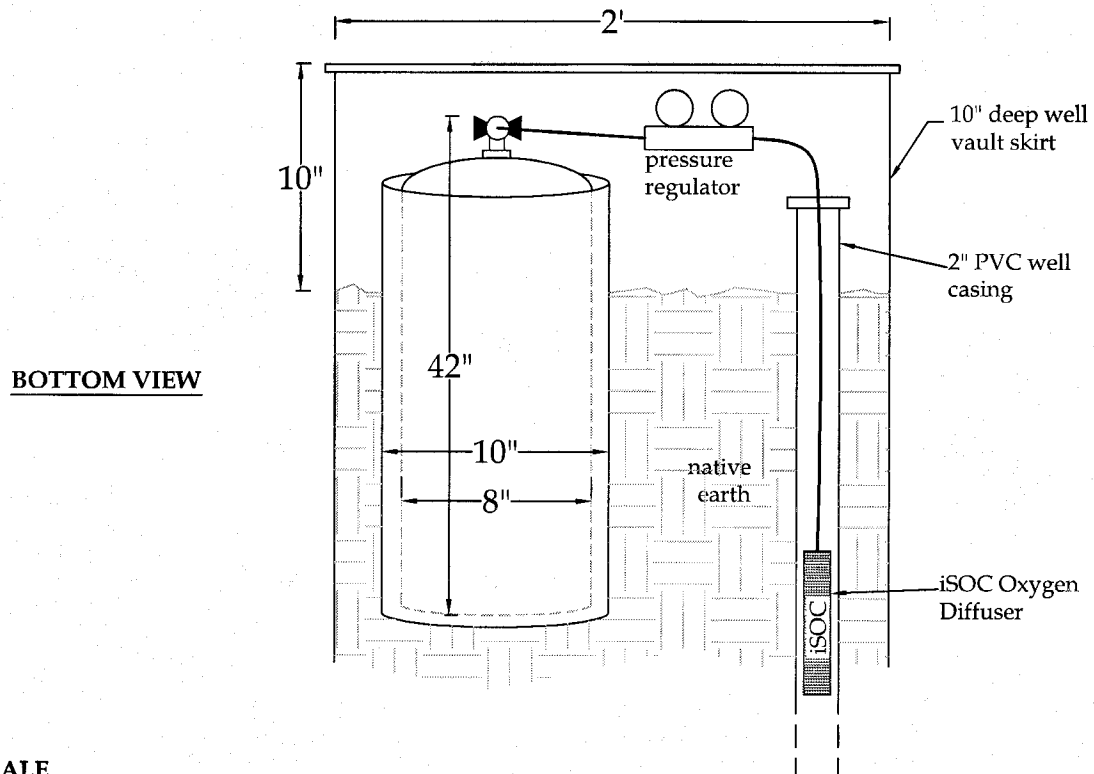
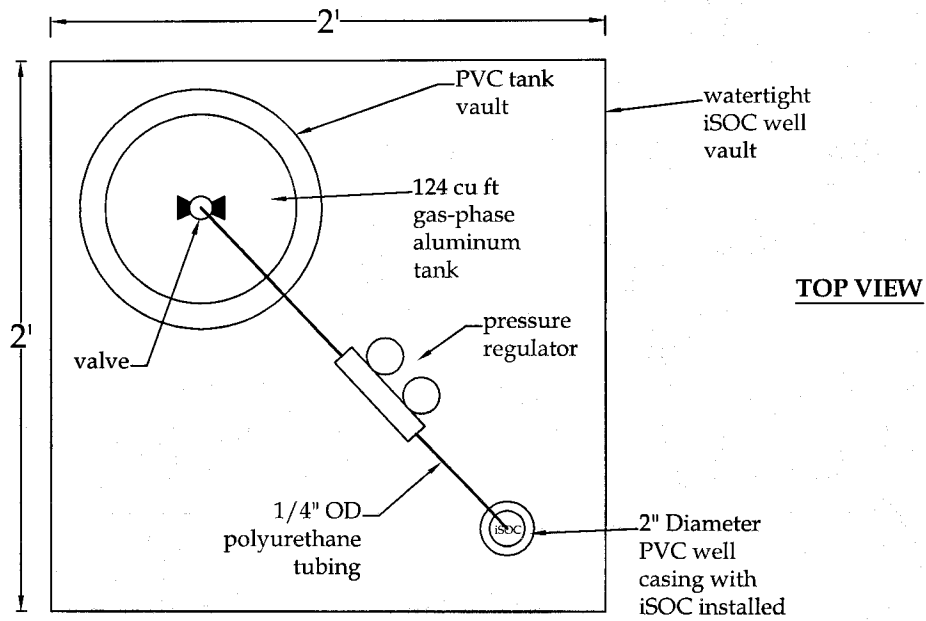
CLEARWATER GROUP

Project No.
ZB308H

Figure Date
3/06

Figure
4





NOT TO SCALE

iSOC Well Vault Diagram

Westport Community Store
37001 North Highway 1
Westport, California

CLEARWATER GROUP

Project No.
ZB308H

Figure Date
3/06

Figure
6

TABLES

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TABLE 1
GROUNDWATER MONITORING WELL CONSTRUCTION DETAILS
Westport Community Store
37001 North Highway 1
Westport, CA
Clearwater Group Project No. ZB308H

WELL No.	CONSTRUCTION Date	WELL		TOTAL DEPTH (feet bgs)	SCREENED INTERVAL (feet bgs)	SAND PACK INTERVAL (feet bgs)	BENTONITE INTERVAL (feet bgs)	CONCRETE INTERVAL (feet bgs)
		WELL CASE DIAMETER (Inches)	BORING DIAMETER (Inches)					
MW-1	13-Jul-99	2	8	21	5-20	3-21	2-3	0-2
MW-2	13-Jul-99	2	8	21	5-20	3-21	2-3	0-2
MW-3	13-Jul-99	2	8	21	5-20	3-21	2-3	0-2
MW-4	13-Apr-00	2	8	21	5-20	4-21	2-4	0-2
MW-5	13-Apr-00	2	8	18	4.5-17.5	3.5-18	1.5-3.5	0-1.5

TABLE 2
SOIL SAMPLING ANALYTICAL RESULTS
 Westport Community Store
 37001 North Highway 1
 Westport, California
 Clearwater Project No. ZB308H

Sample (#)	Sampling Date	TPHg (mg/Kg)	TPHd (mg/Kg)	B (mg/Kg)	T (mg/Kg)	E (mg/Kg)	X (mg/Kg)	MTBE (mg/Kg)	Lead (mg/Kg)
MW-1-10	13-Jul-99	<1	<1	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<5
MW-2-15	13-Jul-99	<1	<1	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<5
MW-3-16	13-Jul-99	<1	<1	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<5
SP-1	13-Apr-00	<1	---	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	11
SP-2	13-Apr-00	<1	---	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	29
SP-3	13-Apr-00	<1	---	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	80
B-1 (17-18)	8/5/2004	<1.0	---	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	---
B-2 (15-16)	8/5/2004	<1.0	---	<0.0050	<0.0050	0.0150	0.0240	0.0520	---
B-3 (18-19)	8/5/2004	<1.0	---	0.0220	<0.0050	<0.0050	0.0065	0.6400	---
B-4 (18-19)	8/5/2004	<1.0	---	0.0087	<0.0050	<0.0050	<0.0050	0.1500	---
B-5 (18-19)	8/5/2004	<1.0	---	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	---

NOTES: SOIL SAMPLES

TPHg Total petroleum hydrocarbons as gasoline using EPA Method 8015/8020(modified)

TPHd	EPA Method 8260B was used during the 2004 event
B	Total petroleum hydrocarbons as gasoline using EPA Method 8015/8020(modified)
T	Benzene using EPA Method 8015/8020 (modified), 8260B in 2004
E	Toluene using EPA Method 8015/8020 (modified), 8260B in 2004
X	Ethyl benzene using EPA Method 8015/8020 (modified), 8260B in 2004
MTBE	Xylenes using EPA Method 8015/8020 (modified), 8260B in 2004
Lead	Methyl tertiary-butyl ether using EPA Method 8260
mg/Kg	Total lead by EPA Method 6010B
<##	Milligrams per kilogram (approximately equal to parts per million)
	Not detected in concentrations exceeding the indicated laboratory reporting limit

TABLE 3
GROUNDWATER ELEVATIONS AND ANALYTICAL RESULTS
Westport Community Store
37001 North Highway 1
Westport, California
Clearwater Project No. ZB308H

Sample (#)	Sampling Date	TOC (feet)	DTW (feet)	GWE (feet)	TPHg (µg/L)	B (µg/L)	T (µg/L)	E (µg/L)	X (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)
MW-1	27-Jul-99	80.00	13.81	66.19	<50	<0.50	<0.50	<0.50	<0.50	36* / 27	<5.0	<5.0	<5.0	<20
	13-Apr-00	80.00	12.18	67.82	68‡	<0.50	<0.50	<0.50	<0.50	96	--	--	--	--
	28-Jul-00	80.00	13.42	66.58	76	<0.50	1.0	<0.50	<0.50	59	--	--	--	--
	1-Nov-00	80.00	14.71	65.29	54‡	<0.50	<0.50	<0.50	<0.50	52	--	--	--	--
	29-Jan-01	80.00	12.38	67.62	66‡	<0.50	<0.50	<0.50	<0.50	100	--	--	--	--
	22-Apr-03	79.41	10.67	68.74	<50	<0.50	<0.50	<0.50	<0.50	160	<0.5	<0.5	<0.5	9
	19-Aug-03	79.41	14.31	65.10	<50	<0.50	<0.50	<0.50	<0.50	160	<0.5	<0.5	<0.5	<5.0
	11-Nov-03	79.41	15.11	64.30	<50	<0.50	<0.50	<0.50	<0.50	63	<0.5	<0.5	<0.5	<5.0
	10-Feb-04	79.41	11.33	68.08	<50	<0.50	<0.50	<0.50	<0.50	150	<0.5	<0.5	<0.5	<0.5
	12-May-04	79.41	12.56	66.85	<50	<0.50	<0.50	<0.50	<0.50	61	<0.5	<0.5	<0.5	<5.0
	3-Aug-04	79.41	14.55	64.86	<50	<0.50	<0.50	<0.50	<0.50	34	<0.5	<0.5	<0.5	<5.0
	1-Nov-04	79.41	14.84	64.57	<50	<0.50	<0.50	<0.50	<0.50	8.7	<0.5	<0.5	<0.5	<5.0
	18-Feb-05	79.41	11.42	67.99	<50	<0.50	<0.50	<0.50	<0.50	120	<0.5	<0.5	<0.5	10
	4-May-05	79.41	11.83	67.58	<50	<0.50	<0.50	<0.50	<0.50	120	<0.5	<0.5	<0.5	11
	3-Aug-05	79.41	13.03	66.38	<50	<0.50	<0.50	<0.50	<0.50	130	<0.5	<0.5	<0.5	14*
MW-2	27-Jul-99	82.18	15.39	66.79	<50	<0.50	<0.50	<0.50	<0.50	<5.0*	<5.0	<5.0	<5.0	<20
	13-Apr-00	82.18	13.82	68.36	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	28-Jul-00	82.18	14.93	67.25	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	1-Nov-00	82.18	16.47	65.71	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	22-Apr-03	81.59	12.11	69.48	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	19-Aug-03	81.59	15.88	65.71	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	11-Nov-03	81.59	16.82	64.77	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	10-Feb-04	81.59	13.31	68.28	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	12-May-04	81.59	13.97	67.62	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	3-Aug-04	81.59	16.07	65.52	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	1-Nov-04	81.59	16.53	65.06	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	18-Feb-05	81.59	Unable to Access TOC											
	4-May-05	81.59	13.32	68.27	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	3-Aug-05	81.59	14.58	67.01	--	--	--	--	--	--	--	--	--	--
MW-3	27-Jul-99	85.96	18.54	67.42	<50	<0.50	<0.50	<0.50	<0.50	<5.0*	<5.0	<5.0	<5.0	<20
	13-Apr-00	85.96	16.83	69.13	68	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	28-Jul-00	85.96	17.97	67.99	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	1-Nov-00	85.96	19.55	66.41	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	29-Jan-01	85.96	17.50	68.46	110‡	<0.50	1.3	<0.50	<0.50	<5.0	--	--	--	--
	22-Apr-03	85.37	15.89	69.48	<50	<0.50	<0.50	<0.50	<0.50	0.99	<0.5	<0.5	<0.5	<5.0
	19-Aug-03	85.37	19.09	66.28	<50	<0.50	<0.50	<0.50	<0.50	0.64	<0.5	<0.5	<0.5	<5.0
	11-Nov-03	85.37	19.82	65.55	Not enough water to collect a sample									
	10-Feb-04	85.37	17.05	68.32	<50	<0.50	<0.50	<0.50	<0.50	0.83	<0.5	<0.5	<0.5	<5.0
	12-May-04	85.37	17.12	68.25	<50	<0.50	<0.50	<0.50	<0.50	1.1	<0.5	<0.5	<0.5	<5.0
	3-Aug-04	85.37	19.32	66.05	Not enough water to collect a sample									
	1-Nov-04	85.37	19.39	65.98	Not enough water to collect a sample									
	18-Feb-05	85.37	16.21	69.16	Well Casing Damaged Unable to Collect Sample									
	4-May-05	85.37	16.43	68.94	<50	<0.50	<0.50	<0.50	<0.50	1.1	<0.5	<0.5	<0.5	<5.0
	3-Aug-05	85.37	17.49	67.88	<50	<0.50	<0.50	<0.50	<0.50	1.0	<0.5	<0.5	<0.5	<5.0

TABLE 3
GROUNDWATER ELEVATIONS AND ANALYTICAL RESULTS
Westport Community Store
37001 North Highway 1
Westport, California
Clearwater Project No. ZB308H

Sample (#)	Sampling Date	TOC (feet)	DTW (feet)	GWE (feet)	TPHg (µg/L)	B (µg/L)	T (µg/L)	E (µg/L)	X (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)
MW-4	13-Apr-00	73.86	8.10	65.76	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	28-Jul-00	73.86	9.92	63.94	81	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	1-Nov-00	73.86	9.64	64.22	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	29-Jan-01	73.86	6.55	67.31	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	22-Apr-03	73.27	5.36	67.91	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	19-Aug-03	73.27	10.31	62.96	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	15-Nov-03	73.27	10.35	62.92	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	10-Feb-04	73.27	5.65	67.62	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	12-May-04	73.27	8.26	65.01	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	3-Aug-04	73.27	10.41	62.86	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	1-Nov-04	73.27	9.57	63.70	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	18-Feb-05	73.27	2.54	70.73	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	4-May-05	73.27	5.85	67.42	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	3-Aug-05	73.27	9.78	63.49	--	--	--	--	--	--	--	--	--	--
MW-5	13-Apr-00	77.68	9.73	67.95	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	28-Jul-00	77.68	11.13	66.55	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	1-Nov-00	77.68	12.28	65.40	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	29-Jan-01	77.68	9.75	67.93	<50	<0.50	<0.50	<0.50	<0.50	<5.0	--	--	--	--
	22-Apr-03	77.09	7.41	69.68	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	19-Aug-03	77.09	11.80	65.29	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	11-Nov-03	77.09	12.61	64.48	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	10-Feb-04	77.09	8.50	68.59	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	12-May-04	77.09	9.88	67.21	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	3-Aug-04	77.09	11.03	66.06	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	1-Nov-04	77.09	12.31	64.78	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	18-Feb-05	77.09	8.51	68.58	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	4-May-05	77.09	9.14	67.95	<50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.5	<0.5	<5.0
	3-Aug-05	77.09	10.49	66.60	--	--	--	--	--	--	--	--	--	--
B-1	5-Aug-04	--	--	--	150	<0.50	<0.50	0.64	1.20	33	<0.50	<0.50	<0.50	<5.0
B-2	5-Aug-04	--	--	--	1,400	<0.50	<0.50	10	16.0	13	<0.50	<0.50	<0.50	<5.0
B-3	5-Aug-04	--	--	--	670	4.90	0.52	0.51	2.90	130	<0.50	<0.50	<0.50	8.80
B-4	5-Aug-04	--	--	--	<50	8.10	<0.50	<0.50	<0.50	93	<0.50	<0.50	<0.50	9.50(j)
B-5	5-Aug-04	--	--	--	<50	<0.50	0.58	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<5.0

TABLE 3
GROUNDWATER ELEVATIONS AND ANALYTICAL RESULTS
Westport Community Store
37001 North Highway 1
Westport, California
Clearwater Project No. ZB308H

Sample (#)	Sampling Date	TOC (feet)	DTW (feet)	GWE (feet)	TPHg (µg/L)	B (µg/L)	T (µg/L)	E (µg/L)	X (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)
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NOTES:

DTW	Depth to water
TOC	Top of well casing (Surveyed to Mean Sea Level [MSL] on April 22, 2003)
GWE	Groundwater elevation relative to MSL (GWE = TOC - DTW)
TPHg	Total petroleum hydrocarbons as gasoline using EPA Method 8015 (modified)
B	Benzene using EPA Method 8020
T	Toluene using EPA Method 8020
E	Ethylene using EPA Method 8020
X	Xylenes using EPA Method 8020
MTBE	Methyl tertiary-butyl ether using EPA Method 8260
DIPE	Diisopropyl ether using EPA Method 8260
ETBE	Ethyl tertiary-butyl ether using EPA method 8260
TAME	Tertiary-amyl methyl ether using EPA method 8260
TBA	Tertiary butanol using EPA method 8260
µg/L	Micrograms per liter (approximately equal to parts per billion: ppb)
<###	Not detected in concentrations exceeding the indicated laboratory reporting limit
--	Sampled not tested for respective analyte
‡	Lab note: "Within quantification range, but atypical for fuel pattern."
*	Initial MTBE readings by EPA Method 8020
B-#	Water sample collected from specific soil boring location
(j)	Laboratory noted that TBA concntration may be slightly biased due to MTBE conversion to TBA

ATTACHMENT A



**California Regional Water Quality Control Board
North Coast Region
Beverly Wasson, Chairperson**



Alan C. Lloyd, Ph.D.
Agency Secretary

www.waterboards.ca.gov/northcoast
5550 Skylane Boulevard, Suite A, Santa Rosa, California 95403
Phone: (877) 721-9203 (toll free) • Office: (707) 576-2220 • FAX: (707) 523-0135

Arnold
Schwarzenegger
Governor

December 21, 2005

Mr. Charles W. Eagleton
16499 Crescent Court
Hidden Valley Lake, CA 95461

Dear Mr. Eagleton:

Subject: December 7, 2005 Monitoring Report, Third Quarter 2005
File: Westport Community Store, 37001 North Highway 1, Westport, California
Case No. 1TMC404

Thank you for the December 7, 2005 *Monitoring Report, Third Quarter 2005* (report), submitted by Clearwater Group, for the Westport Community Store located at 37001 North Highway 1 in Westport. According to the report, groundwater samples collected from monitoring well MW-1 and MW-3 continue to indicate the presence of MTBE. In addition, TBA has been present in the groundwater samples from MW-1 since February of 2005.

The report recommended that an interim remedial action plan be prepared to address the presence of the MTBE. Regional Water Board staff concurs with this recommendation. Please submit a workplan that describes in detail the proposed interim remedial action no later than February 28, 2006.

You may contact me via the Internet at Brolandelli@waterboards.ca.gov or at (707) 576-2667 if you have any questions.

Sincerely,

Bonnie Rolandelli
Engineering Geologist

BAR: 12-21-2005_bar_westport8.doc

cc: Mendocino County Health Department, 501 Low Gap Road, Room 1326,
Ukiah, CA 95482
Jessica Chiaro, Clearwater Group, TAG Inc., 229 Tewksbury Avenue, Point Richmond,
CA 94805
James Jacobs, Clearwater Group, TAG Inc., 229 Tewksbury Avenue, Point Richmond, CA
94805
Jeff Delgado, SWRCB, Underground Storage Tank Cleanup Program (Claim #014259)

California Environmental Protection Agency

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ATTACHMENT B



ABSOLUTE OZONE™

GETTING THE MOST OUT OF OZONE GENERATOR TECHNOLOGY

HOME | PRODUCTS & PRICES | APPLICATIONS | TECHNICAL | WARRANTY | SERVICES | CONTACT | REQUEST INFORMATION

Making Informed Technology Decisions? We understand you need solid information before n

APPLICATIONS:

- ✦ Bottled Water
- ✦ Industrial Processes
- ✦ Aquaculture
- ✦ Pharmaceutical
- ✦ Food Processing
- ✦ Soil remediation
- ✦ Wineries
- ✦ Cooling Towers
- ✦ Potable Water Disinfection
- ✦ Waste Water Treatment

KEY OZONE FEATURES

- ✦ 12 times more soluble than oxygen in water
- ✦ Moves easily through the soil
- ✦ Produced on-site, no need for hazardous chemical transportation or storage
- ✦ Most powerful oxidizer available
- ✦ Complex organics break down to carbon dioxide or less toxic molecules

WHY USE OZONE FOR SOIL REMEDIATION

Ozone Treatment has evolved from water treatment to remediation. Recently, ozone has been used to clean up sites containing variety of soil contaminants. The reason for using ozone is to target those compounds that are not biodegradable or the ones which are biodegradable over a long period of time.

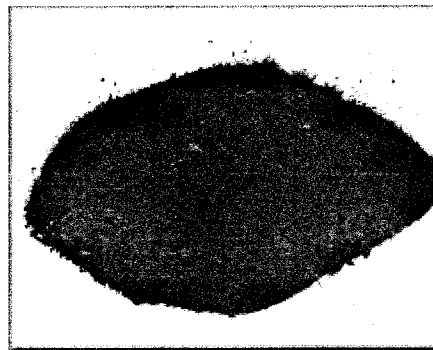
Many hydrocarbon compounds will biodegrade if they are dissolved, although these contaminants are not readily biodegraded by microorganisms if they are on soil particles.

In addition to other reasons in some cases ozone soil remediation method is selected because of the network of water pipes and utility lines through a site makes it impossible to excavate the contaminated soil.

Often, when treated with ozone sites show 99% reduction of contaminants which is pretty incredible.



Soil contaminated with oil & fuel



Soil after remediation

KEY BENEFITS

- ✦ *Low capital equipment costs*
- ✦ *Minimal site disturbance during installation*
- ✦ *Low on-site profile*
- ✦ *Low operating costs*
- ✦ *In-situ destruction of targeted components*

- Breaks down to oxygen which increases DO levels

CONTAMINANTS DESTROYED BY OZONE

- MTBE
- BTEX
- Hydrocarbons
- Diesel Fuel
- TCE
- Pesticides
- Chlorinated Solvents
- VOC's
- Aliphatic & Polyaromatic Hydrocarbons

- *Rapid decrease of contaminant mass and concentration in soil and water - impressive results may be seen in weeks*
- *No vapour control necessary - contaminants are destroyed rather than transferred from one phase to another*
- *Clean reaction - no hazardous by-product formation*
Microbubble size and means of introduction into the interstitial spaces of the formation ensures maximum contact with contaminant
- *Microbubbles act to extract VOCs from groundwater and soil pores which reduces soil oxidative demand common to liquid oxidants*

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In-Situ AOP Technology Eliminates 800 Foot Petroleum Plume in 5 Months

PLEASANT HILL, CALIFORNIA, Jan. 31 -/E-Wire/-- GROUNDWATER & ENVIRONMENTAL SERVICES, INC. (GES) of Neptune, New Jersey, and APPLIED PROCESS TECHNOLOGY, INC. (Applied) of Pleasant Hill, California, together have developed and implemented an advanced oxidation process (AOP) technology for the rapid and low-cost removal of contaminants in soil and groundwater. The process combined Applied's revolutionary PulseOx chemical oxidation technology with GES's innovative Max-Ox nested injection well delivery mechanism to eliminate an 800-foot plume of petroleum constituents within five months.

PulseOx equipment was used to aggressively oxidize groundwater contaminants by pulsing and cycling four different reagents—ozone, hydrogen peroxide, oxygen, and air—in precise, pre-programmed dosages, sequences, and combinations into Max-Ox injection wells. This technique hastened cleanup through several rapid processes: chemical oxidation via ozone injection, hydrogen peroxide injection, and hydroxyl radical reaction; enhanced bioremediation via high dissolved oxygen levels; and mass transfer of volatile organic compounds via air injection. Max-Ox technology maximized the distribution of oxidants in the subsurface, expanding their radius of influence 15 feet or more around each injection point. The formation of hydroxyl radicals, which are powerful oxidizers, accelerated the degradation of contaminants to carbon dioxide and water.

Prior to treatment, hydrogeologic investigation had revealed that the plume extended under several properties and had impacted local private drinking wells. Pre-remediation concentrations of contaminants were noted at up to 26,300 micrograms per liter (µg/L) of methyl tertiary butyl ether (MTBE), 27,000 mg/L of tertiary butyl alcohol (TBA), and 26,300 µg/L of the gasoline constituents benzene, toluene, ethylbenzene, and xylenes (BTEX).

The cleanup process was started in October 2002. Within five months, there were no detectable contaminants in soil or water, exceeding even the original estimates of an aggressive nine-month treatment. Regulators at Delaware Department of Natural Resources and Environmental Control (DNREC) approved site closure in July 2004, after one year of groundwater monitoring showed no rebound in contaminants. What's more, DNREC recognized this success story in the Spring 2003 issue of its Think Tank publication.

"We evaluated many traditional and innovative options, and selected chemical oxidation as the fastest and most cost-effective way to achieve closure,"

stated Chuck Whisman, GES's director of engineering. "Our innovative and safe approach met our client's business objectives and was enthusiastically approved by regulators and the community."

"The results achieved at this site clearly indicate that the unique combination of PulseOx and Max-Ox technologies is very effective, aggressive, and accelerates the time required to close a treatment site," says Terry Applebury, Applied's president and chief executive officer. "Applied is very pleased to have participated with GES in this extremely successful in-situ treatment project."

Applied Process Technology, Inc. (Applied) provides technically superior pump-and-treat and in-situ water treatment solutions and services to the drinking water, environmental remediation and industrial process water markets. Applied specializes in treatment technologies that do not generate by-products or waste streams. Its HiPOx and PulseOx products utilize advanced oxidation and chemical oxidation processes that destroy a wide variety of contaminants including 1,4-dioxane, MTBE, TBA, and more. Applied and its alliance partners offer other technologies that treat a variety of contaminants, including perchlorate. New advanced products are under development. (www.aptwater.com) Groundwater & Environmental Services, Inc. (GES) is a full-service environmental consulting firm specializing in soil and groundwater contaminant assessment and remediation. GES, now celebrating its 20th anniversary, has 30 offices with 500 hands-on professionals serving clients across the country. The company delivers responsive, innovative, and cost-effective environmental solutions to expedite site investigation, cleanup, and closure, and safely restore property value. (www.gesonline.com)

/SOURCE: Applied Process Technology, Inc.

-0- 01-31-2005

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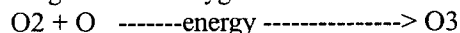
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Ozone Oxidation Capabilities

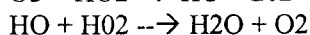
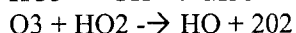
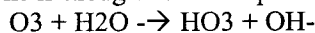
Written by: Amir Salama P.Eng, M.Sc.

Introduction

Discovered in the 19 Th. century Ozone a natural form of activated oxygen (allotropy) generally produced during lightning storms and continuously occurring in the stratosphere due to action of ultraviolet (UV) is being rediscovered for the 21 Th. century. It can be artificially produced by the action of high voltage discharge in air or oxygen.



Ozone is highly unstable and must be generated on site. Its oxidation potential (-2.07V) is greater than that of hypochlorite acid (-1.49V) or chlorine (-1.36V), The latter agents being widely used in water treatment practice. Ozone is thought to decompose accordingly (Miller 1978, 167-168):



This unstable form of oxygen breaks down to oxygen molecules and oxygen atoms which have high oxidation potential. If we examine the oxidation power of Ozone by measuring the REDOX potential will find out that O₃ is about 5 times more oxidising than oxygen & about twice as much as Chlorine. These high potentials increase its reactivity with other elements and compounds. This reactivity is about 20 to 50 times more reactive than chlorine and Permanganates as it is well documented in the case of the high kill rate of micro-organisms (Funguses, Bacteria & Viruses). This high kill rate means smaller retention times, storage tanks, are required to do the same disinfecting as other oxidants. In other words the capital cost for building these tanks and treatment plants are reduced considerably.

Ozone is a God given gift as it will reduce chemical handling, storage, transportation infrastructure and production facilities. Ozone requires only electricity which is readily available from hydro, solar, wind or fuel electric generators. In many instances O₃ will allow decentralisation of services which will provide better flexibility and better cost management. Here is non exhaustive list of Ozone applications where data & references are available:

Ozone chemical free treatments and applications

<u>Waste water effluents</u>	<u>Industrial /Agriculture</u>	<u>Food Industry</u>	
<u>Others</u>			
Domestic/Municipal Pulp & paper	Cooling towers treatment Boiler water treatment	Drinking & water bottling Grain silo disinfecting	Smoke & odour treatment Semiconductor wafers clean
Mining (Cyanide,Arsenic) Pharmaceutical (Phenol)	Chilled water treatment Cutting fluids recycling	Fruit & vegetable storage Meat storage	Laundry water recycling Med. instrument sterilisation
Textile	Barn disinfecting (air/water)	Slaughter house disinfecting	Hospital air sterilisation
Leather Petroleum/Petrochemicals	Hydroponics Animal waste treatment	Fruits & vegetable wash Food containers sterilisation	Aqua-culture Paper pulp bleach
Electroplating	Water dripping treatment	Wine/Beer SO ₂ replacement	Sour gas desulfurisation
Heavy metal precipitation Landfill leacheates	Animal drinking water Irrigation water disinfecting	Chicken egg wash Ozonated meat grinders	Zebra mussels treatment Rubber recycling,.....etc.

The question we should ask is if O₃ is so good why O₃ is not widely spread ? The answer is simple which is up to recent times Ozone generators (mid-range) were very expensive with an average of cost of \$ 7000 US/Lb/day with advent of new materials,power supplies,high frequency generators prices are starting to go down around \$ 4000 US/Lb/day with an outlook in the near future around \$ 2000/Lb/day or even lower at this level of prices Ozone will compete with the other oxidising alternatives such as Chlorine, Hydrogen peroxides,.....etc.

The time has come where this chemical free technology is an affordable reality.

Design consideration

This section examines the different design considerations which must be made when designing an ozone treatment system. The following topics are discussed:

- 1) Organic and inorganic load
- 2) Ozone dissolution
- 3) Ozone injection alternatives
- 4) Post ozonation requirements

*** Organic and Inorganic Load**

The reaction of ozone with most organic compounds may be modeled using a first order kinetic equation:

$$\ln (C/C_0) = -kt \quad (1)$$

where k is the reaction rate constant. The value of k is found by carrying out laboratory experiments. Typical values range from $4 \times 10^{-3} \text{ sec}^{-1}$ to $4 \times 10^{-4} \text{ sec}^{-1}$. The value of k measured under ambient conditions and neutral pH may be adjusted to account for the effects of pressure, temperature and pH as follows:

$$k'' = k'(b P/P_a)(c T/T_a)(d pH/7)$$

(2)

where the subscript (a) represents ambient conditions.

Although Eq.2 implies that the reaction rate increases with increasing temperature, as is generally the case, it must be kept in mind that ozone solubility is adversely affected by increasing temperature. The effect of pH is illustrated in Figure 1.

The effects of these variables are captured in OZOCAL, a software developed by Ozomax Ltd. OZOCAL estimates the ozone dosage required to treat a given effluent based on its analysis. Typically, for organic contaminants 0.1 to 1.6 g O₃/g COD is needed. The oxidation of heavy metals such as iron and manganese if present alone generally occurs in stoichiometric proportions.

*Ozone Dissolution (Mass Transfer)

For the diffusion of ozone from a gas bubble to an aqueous fluid the boundary conditions are such that the Fick's law simplifies to,

$$N_A = d_L * C \quad (6)$$

where C is the ozone concentration within the bubble and d_L is the mass-transfer coefficient as defined in Eq. 7,

$$d_L = 2D_{AB}/D_p + N \quad (7)$$

where D_p is the bubble diameter and N is a function of the Schmidt Number.

Equations 6 and 7 reveal two very important characteristics of ozone dissolution.

- 1) O₃ dissolution increases with the gaseous ozone concentration
- 2) O₃ dissolution increases with decreasing bubble diameter.

To take advantage of these two points the ozonator must be designed to efficiently dissipate heat which would otherwise cause the premature conversion of the ozone to oxygen thus lowering its concentration. Also, an oxygen feed may be used to yield higher ozone concentrations than those obtained from air. (See Figure 2) Secondly, the ozone/water contact should be made under pressure in order to produce small bubbles. (See Figure 3)

The maximum number of moles of O₃ transferred to the solution may be calculated from,

$$M_{O_3} = N_A * S * t \quad (8)$$

where S=total bubble surface area

t = contact time

This reveals a third important ozone dissolution characteristic:

- 3) O₃ dissolution increases with increasing retention time

Equation 8 also confirms point (2) above.

In summary when ozone is used to treat water or wastewater, it must be transferred from the gas phase, in which it is generated, to the liquid phase. Ozone is 12.5 times more soluble in water than oxygen.

The single most important variable that affects ozone mass transfer is the concentration of dissolved ozone- reactive materials in the water. Ozomax ozonators will produce O₃ concentrations from about 4 to 10 % with Oxygen feed however, the optimum concentrations for generating ozone are 5-6% wt with oxygen used as the feed gases.

*** Ozone Injection**

The principle methods currently used to introduce ozone into water and wastewater are:

- 1) contact column
- 2) venture injection
- 3) centrifugal injection

***Post-Ozonation Requirements**

The ozonation treatment step is usually followed by :

1)Clarification: to precipitate oxidized organic and inorganic matter

2)Filtration

(nano, sand, charcoal): to remove precipitants. The use of activated carbon filters has the added advantage of adsorbing the excess unreacted, unrecycled ozone and allows it to convert back to oxygen.

3)O₃ destruct in air vents: may be accomplished using thermal, catalytic or ultraviolet destruction

Oxidation Mechanism

The free radicals (H₂O₂ and HO) react with a variety of impurities such as metal salts, organic matter including micro organisms, hydrogen and hydroxide ions. They are more potent germicides than hypochlorite acid by factors of 10 to 100 fold and disinfect 3125 times faster than chlorine (Nobel 1980).

Oxidation potential does not indicate the relative speed of oxidation nor how complete the oxidation reactions will be. Complete oxidation converts a specific organic compound to carbon dioxide and water. Oxidation reactions that take place during water treatment are rarely complete, due to the large quantity of contaminants and relatively short durations of time in which to oxidize the water pollutants.

Therefore, partially oxidized organic compounds, such as aldehydes, Carboxylic organic acids are produced during the relatively short reaction periods.

These aldehydes and carboxylic acids can be removed by other means prior to complete mineralisation to reduce the amount of Ozone needed for complete oxidation of these chemicals.

There are three fundamental mechanisms which apply to the oxidation of organic compounds reacting with an oxidizer. Each mechanism is unique as to how organic compounds react with an oxidizer. But, in some cases, oxidants will react with organic compounds by all three mechanisms, although in sequential steps.

First. The addition mechanism which occurs with organic compounds containing aliphatic unsaturates, such as olefin. Ozone can add across a double bond to form an ozonide.

This reaction occurs readily in nonaqueous solvents, but as soon as water is added, the ozone hydrolyzes to other products, with cleavage of the former double bond .

Second. The substitution mechanism involves replacement of one atom or functional group with another.

This specific reaction also can be viewed as an insertion reaction, whereby oxygen is inserted between the ring carbon and hydrogen to form the hydrogen group on the ring .

Oxidation also can involve cleavage of carbon-carbon bonds to produce fragmented organic compounds.

Effect of Temperature and PH

It is clear that other parameters affect the reaction mechanism and rates as found by various studies. The effectiveness of ozone to oxidise organic and inorganic compounds is function of to the temperature of the water and pH levels. In wastewater applications there are many variables such as: water temperature, pH, COD, BOD, TSS, heavy metals, which need to be considered.

Ozone, at low pH levels (less than 7), reacts primarily as the O₃ molecule by selective and sometimes relatively slow reactions. Ozone at elevated pH (above 8) rapidly decomposes into hydroxyl free radicals, which react very quickly. Many compounds that are slow to oxidize will oxidize rapidly when the pH is adjusted to the Alkaline side. It was found that PH=8-10 is most suitable for organic molecules oxidation.

The initial step of the decomposition of ozone is the reaction between ozone and hydroxide ion to form ozone ion and hydroxyl radical (OH⁻): The hydroxyl radical then reacts further. This process would explain the increased dissociation of ozone with increasing alkalinity. Recently, studies have shown experimentally that as pH increases, the kinetics of ozonation of organic compounds changes. Hydroxyl radicals may be the important active species in ozonation as has been concluded (Glaze 1980).

Therefore, the alkalinity of the water is a key parameter in advanced oxidation processes. Ozone then decomposes rapidly in water with a half life of a few minutes about 20 minutes in room temperature but could be much faster less than 10 minutes in the presence of bicarbonate and carbonate ions which are excellent scavengers for free radicals.

In addition, carbonate ions are 20 to 30 times more effective in scavenging for hydroxyl free radicals than bicarbonate ions. For that reason we stated that the pH of 8.0 to 10.0 is most appropriate for ozonation as it was found that at that PH > 10 the bicarbonate ions convert to carbonate ions (EPA 1989).

Effect of catalysts :

There are several catalysts used in conjunction with Ozone such as semi-precious and precious metals, ultrasonic agitation, H₂O₂, electro-coagulation but the most commonly utilised and well documented are the ultraviolet rays at wave length of 254 nm..

Ultra-Violet has been found in the past 10 to 15 years that when this treatment is combined with Ozone there is a rather «explosive» reaction as the two in a sense «destroy» each other creating a highly reactive Hydroxyl ion. The end results of this is that many compounds that neither UV or Ozone independently can remove, however with the combination of these compounds can be removed and the rate of removal is extremely rapid. Sometimes in as little as two seconds. The produced free radicals of this reaction contain at least four radicals: (O) Excited Atomic Oxygen species, (HO) Hydroxy radicals, (HOO) Hydroperoxy radicals and Excited Carbon containing species.

Compounds normally refractory or slow reacting to Ozone or UV alone but which react to the combination of such organo metallic complexes, Cyanides, Phosphorous and nitrogen compounds

Ultrasounds has not been fully exploited as applied to waste water treatment nor fully understood nor documented at present. It is known that in many cases it works with the Ozonation treatment in ways quite similar to UV. Principally it excites the ionic structure of both the water and the contaminants in the waste stream and as a result the Ozonation process is expedited (either in speed of reaction or it actually causes a reaction where the contaminant had been refractory to the Ozone treatment).

ELECTRO-COAGULATION is the process of applying a direct or alternating electrical current and voltage of varying strength to electrodes contacting water or waste water which results in the formation of Floc which can be filtered to remove suspended and flocculated substances. The mechanism by which this flocculating occurs are complicated and involve the inter conversion of electrical and chemical energies reacting with and on substances in the water or waste water.

Waste waters which are slightly reactive to Ozone show excellent reaction with the Electrochemical method such as for domestic and textile waste waters. Ozomax own a patent pending Ozone electrolytic reactor which exploits the advantages of combining ozone and electrolytic processes.

Precious and semi precious metals catalysts studies by Ozomax Ltd were made at McGill University in Montreal showed that the presence of such metals speed up the reaction rates which in some cases can double or triple. 100 % mineralisation occurs when combining these types of catalysts with Ultra violet at 254 nm.

Conclusion

This quick synopsis about ozone usage and applications shows that it is simple and easy to use once it is understood. All variables such PH, temperatures, pressures and catalysts were captured in a software developed by Ozomax Ltd which can predict the ozone quantities required to treat a certain flow rate of a given chemical analysis.

But it is now obvious that Ozonation should now be considered in treating difficult waste waters (heavy metals, textile effluent, plating... without or minimal use of other chemicals.

Remediation of TPH and MtBE Using Ozone Sparging, Under California's Pay-for-Performance Program

**NGWA - Petroleum Hydrocarbons
and Organic Chemicals in Groundwater
Costa Mesa, California
August 20-22, 2003**

**Christine Manhart and Christopher Watt
LACO ASSOCIATES, Eureka, CA**



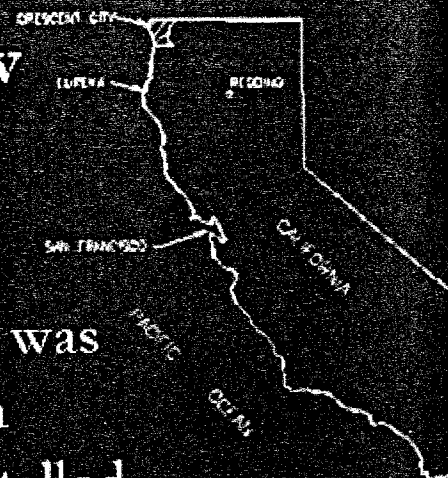
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Project Overview

The site is an active service station in Crescent City, California

Approx. 750 cy of contaminated soil was excavated during the tank removal in 1991. 1998-compliant tanks were installed in 1993.

LACO began monitoring groundwater in 1995, at which time TPHg concentrations were up to 100,000 ug/l and MtBE concentrations were up to 10,000 ug/l. The MtBE plume was approx. 300 feet in length and may have intercepted or flowed under an unused domestic well.



2/25

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Project Overview (Cont.)

The benzene plume extended approx. 175 feet.

At the start of remediation, we estimated there to be 200 gal (750 L) NAPL, 700 kg sorbed phase TPH, 1.5 kg dissolved-phase BTEX, and 5 kg dissolved-phased MtBE.

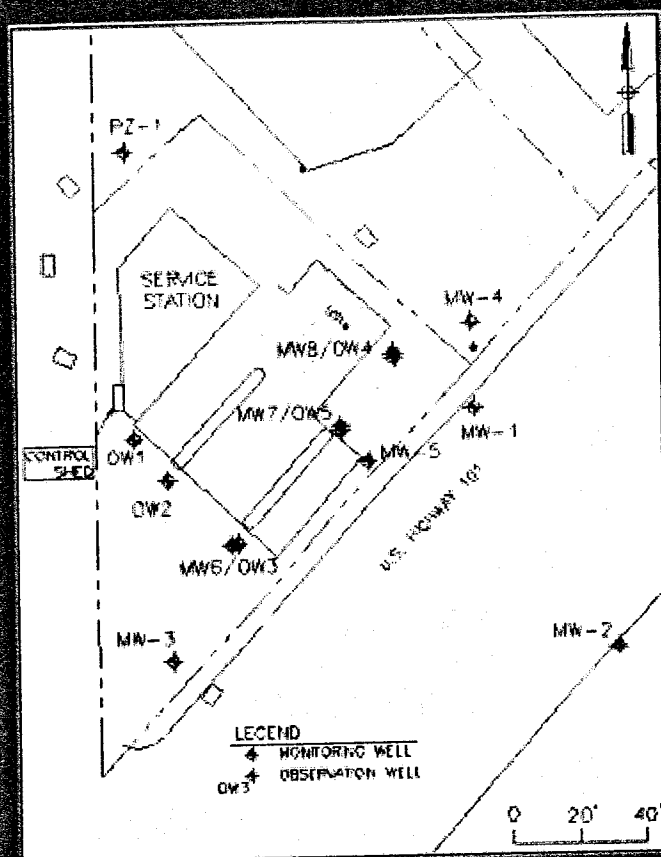
By early 2002, a Corrective Action Plan for ozone sparging was approved by the North Coast Regional Water Quality Control Board.

Installation of the ozone system began in mid-October 2002 and sparging began in early November.

3/25

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Monitoring Well Network



Site map with monitoring well network

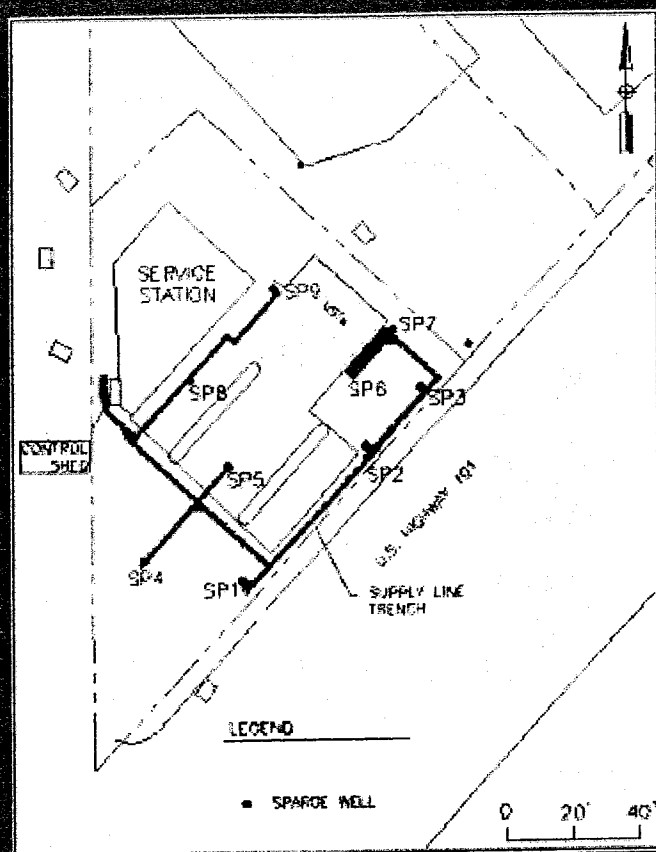
"MW" wells are generally screened from 5'-15' bgs; "OW" wells are screened from 5'-10' bgs

Three new monitoring wells screened from 10'-15' bgs were paired with existing OW wells.



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Sparge Wells and Trench Network



16 Sparge points are installed in 9 wells.

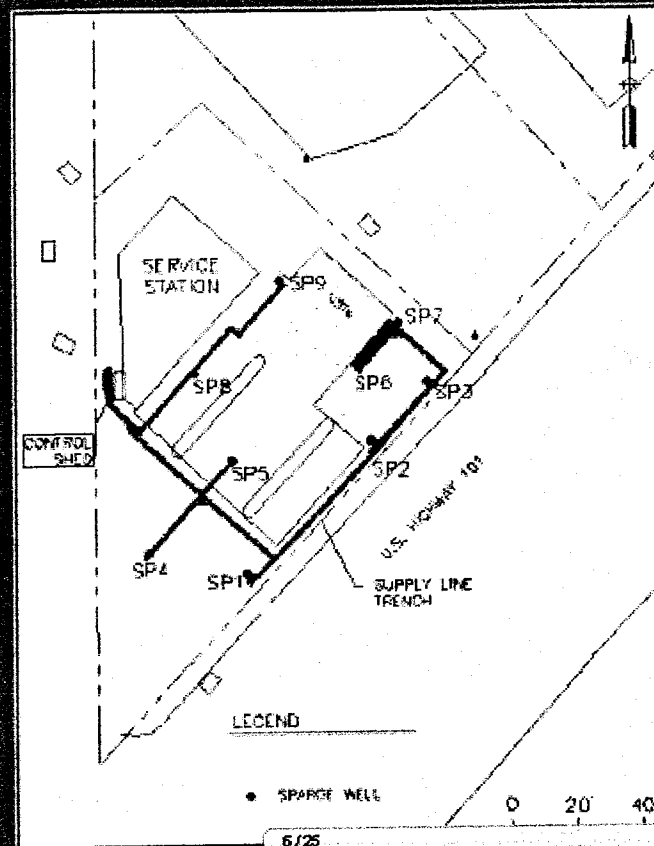
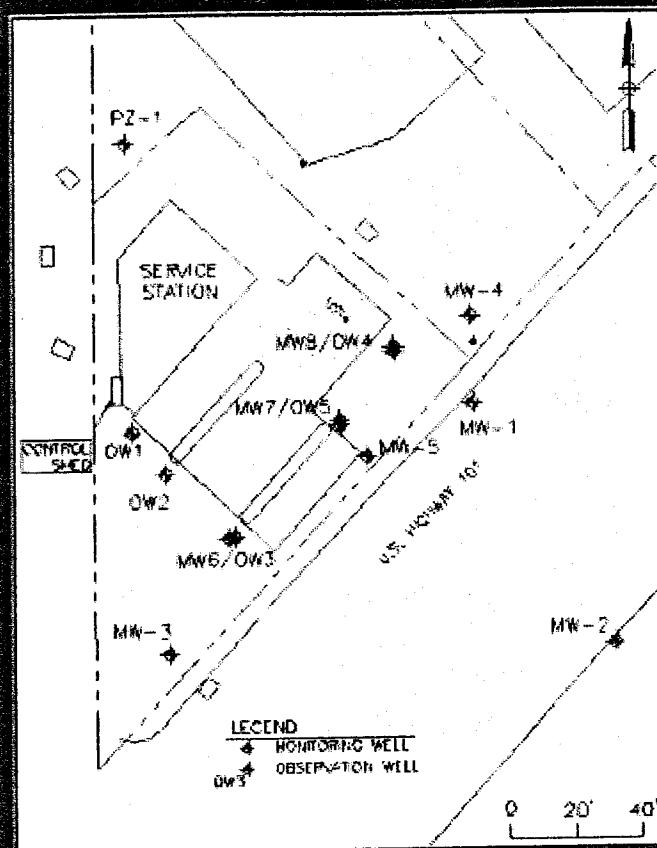
Single point wells located 10' bgs, are farthest up-gradient, closest to the building.

The three wells closest to the highway angled at 30 degrees to treat inaccessible soil.

5/25

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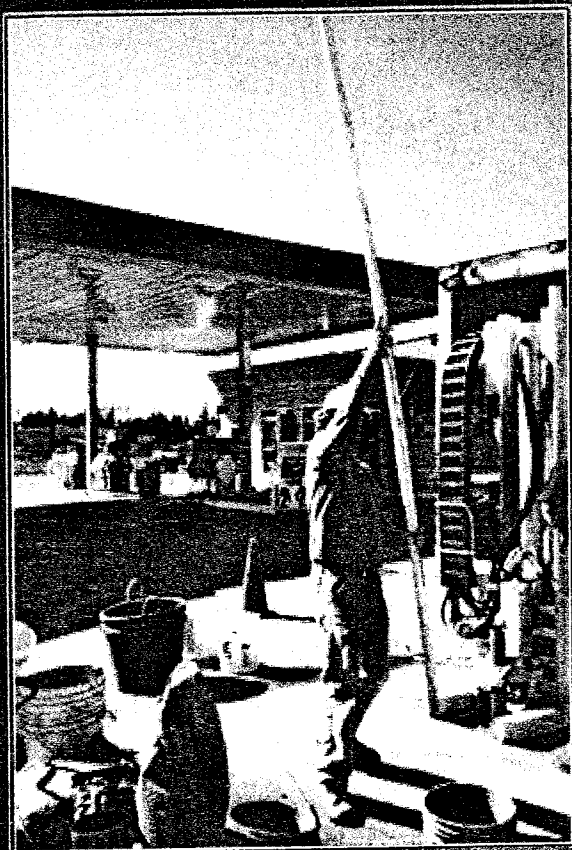
Monitoring and Sparge Well Networks



6/25

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Sparge Well Installation



Sparge wells were installed using direct push and rotary hollow stem auger rigs.

Each dual-point well contains two sparge points located at 15 and 20 feet bgs.

Wells closest to the highway were angled at 30 degrees.

1/25

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Trench Installation



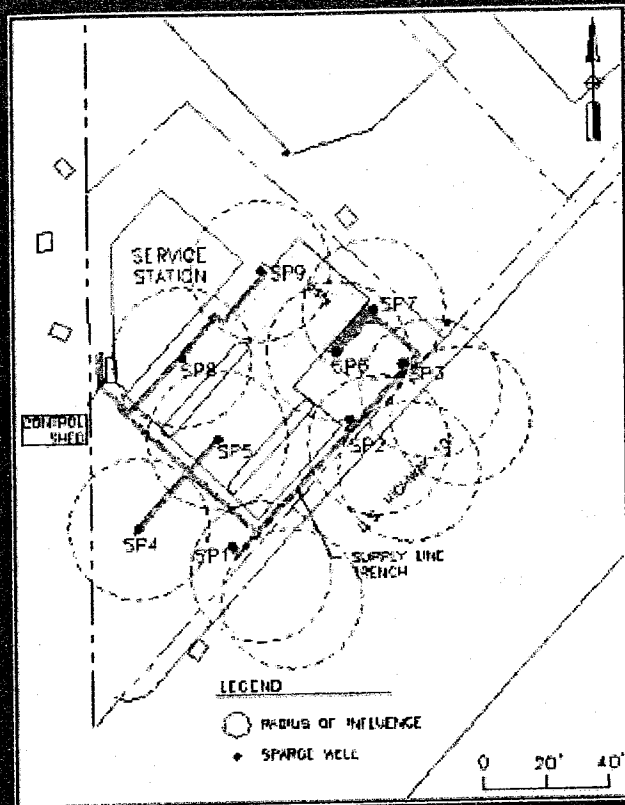
Trenches were installed following the sparge wells.

Trenches are approx. 12" deep by 12" wide, and include rebar reinforcement

8/25

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Radius of Influence of Sparge Wells



The radius of influence was calculated from critical pressure to induce flow, a function of line and point losses, hydraulic head, and formation loss.

Field and analytical screening indicates that these may represent minimums.

9/25

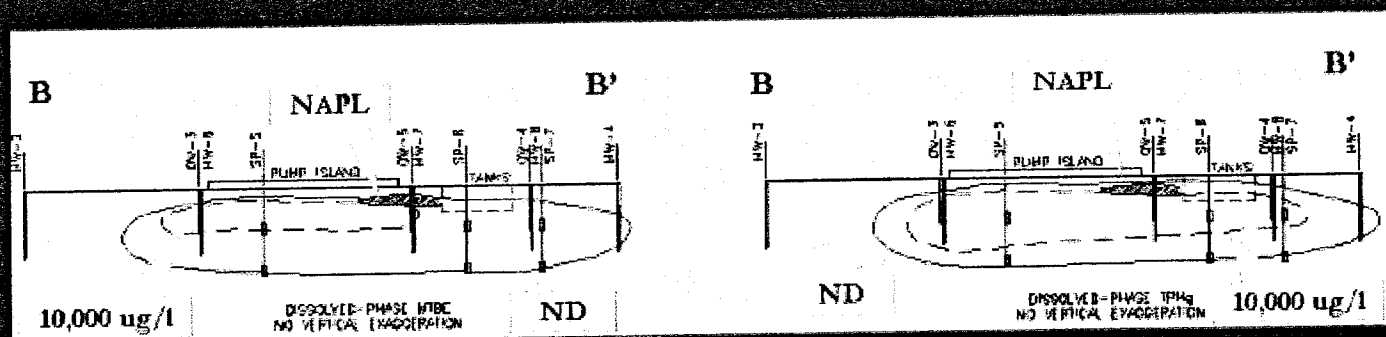
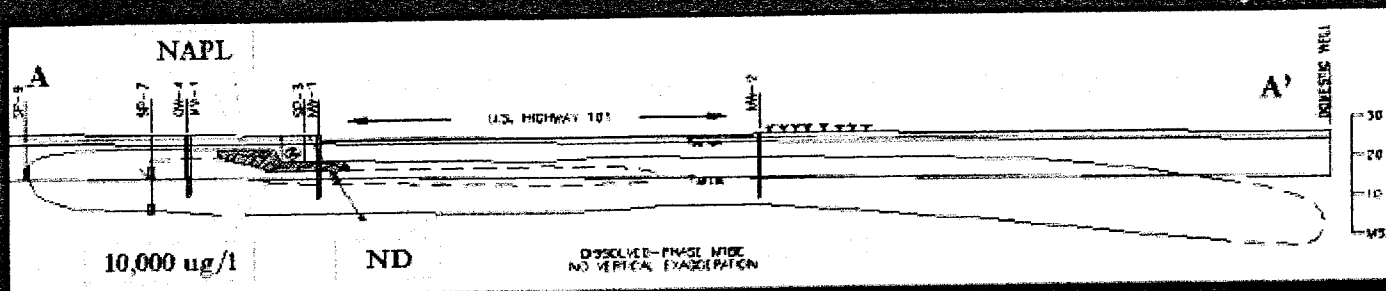


NEXT



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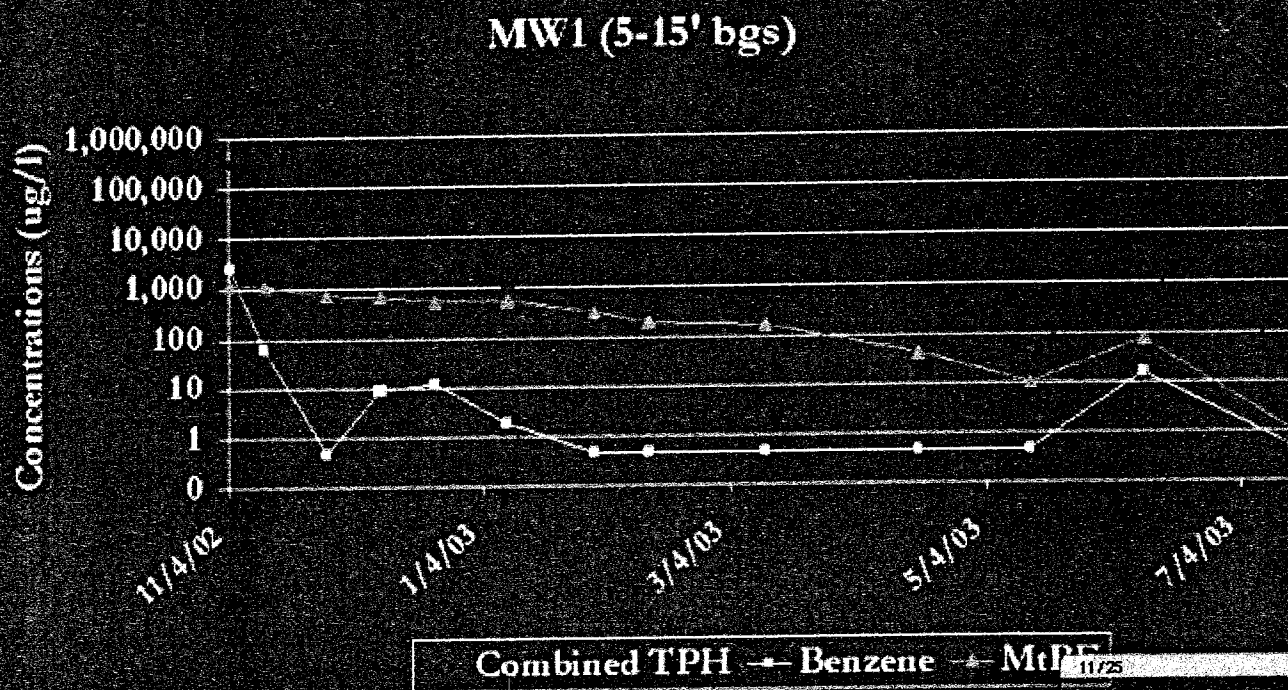
Pre-Treatment Dissolved-Phase Plumes of MtBE and TPHg in Cross-Section



10/25

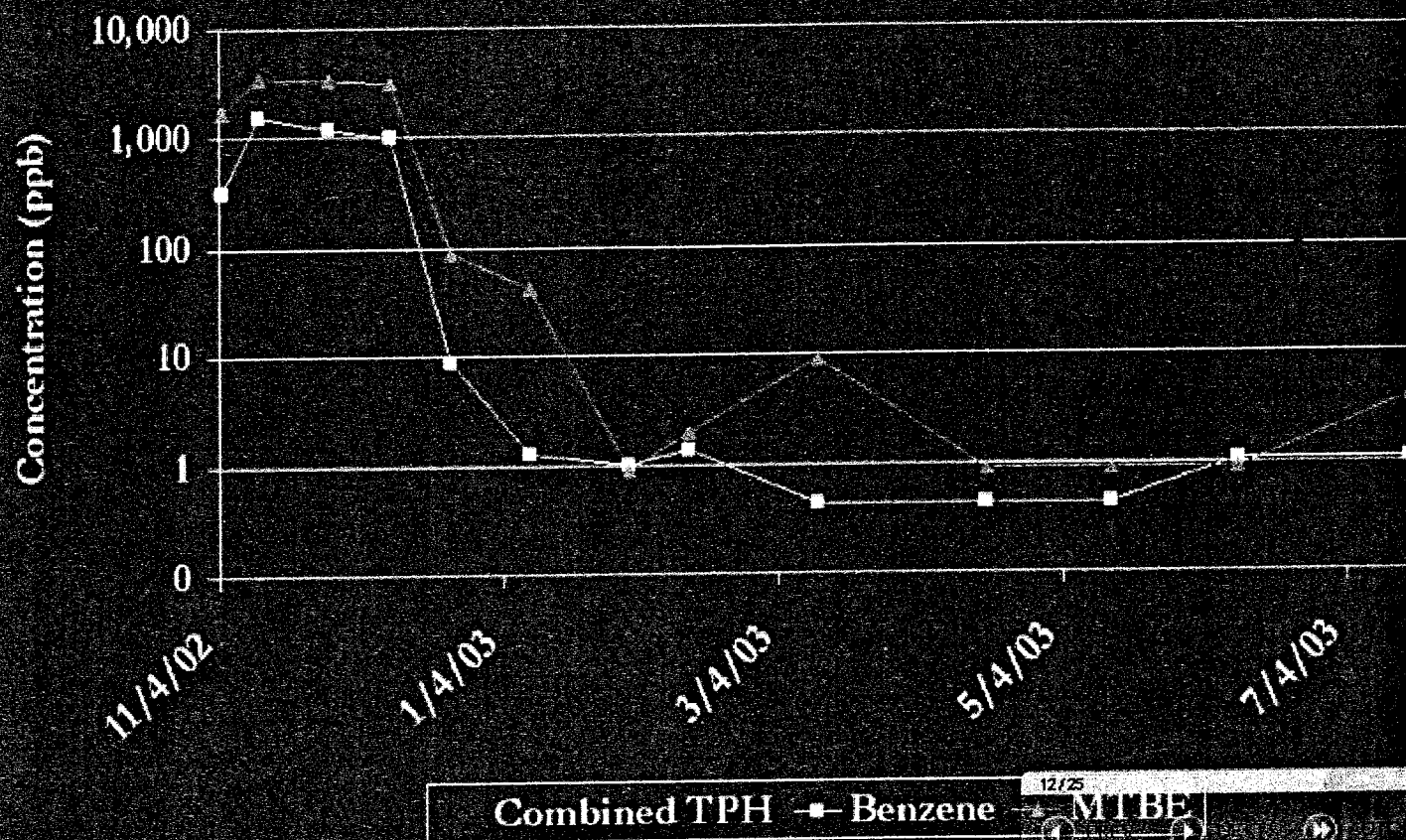
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TPH, Benzene, and MtBE in MW1



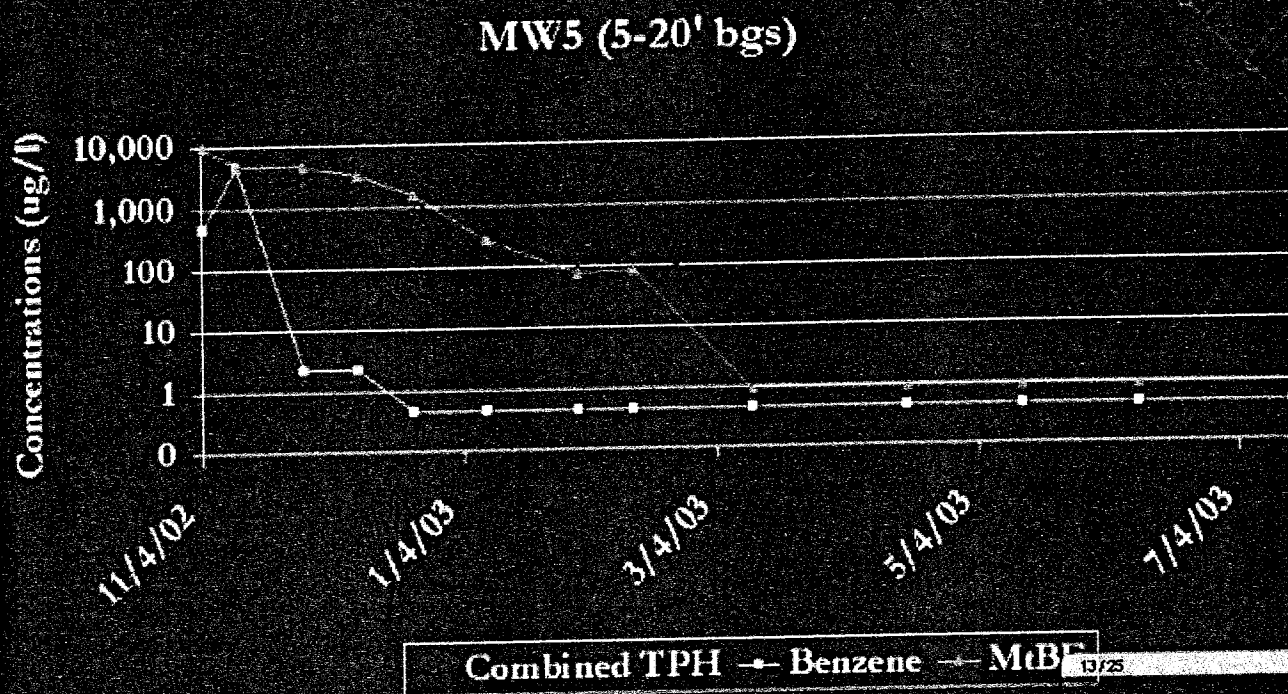
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TPH, Benzene, and MTBE in MW2



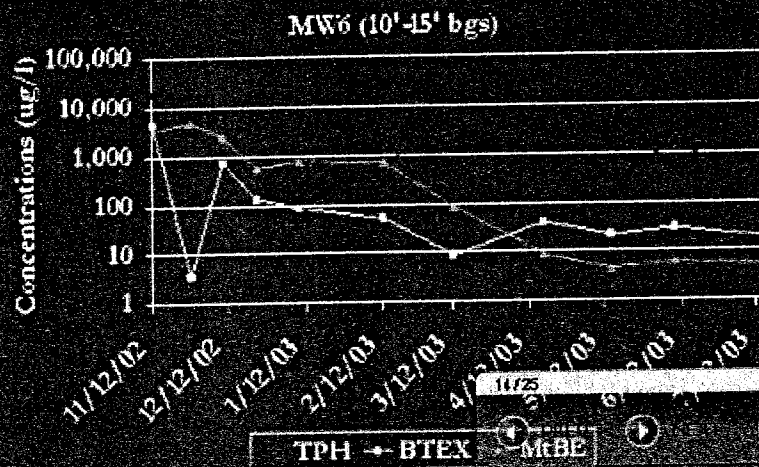
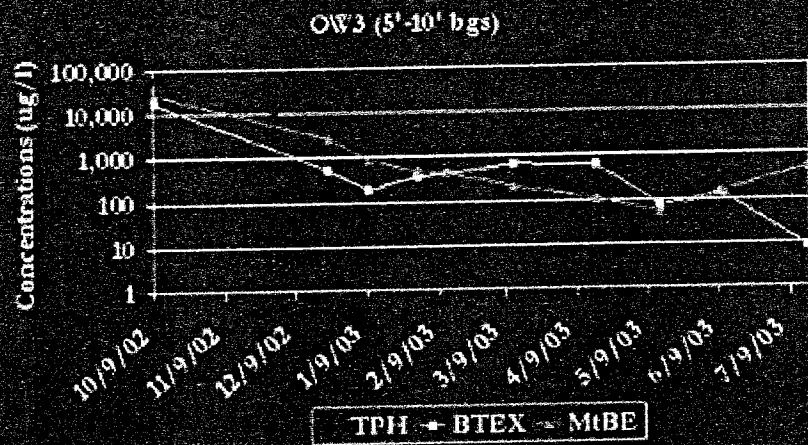
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TPH, Benzene, and MtBE in MW5



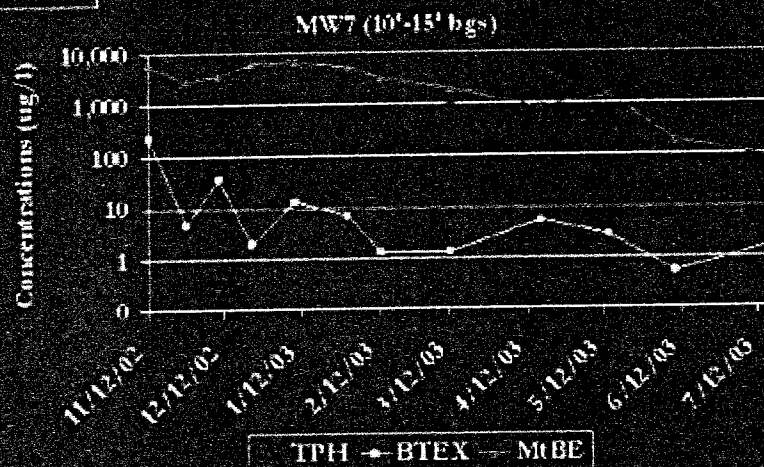
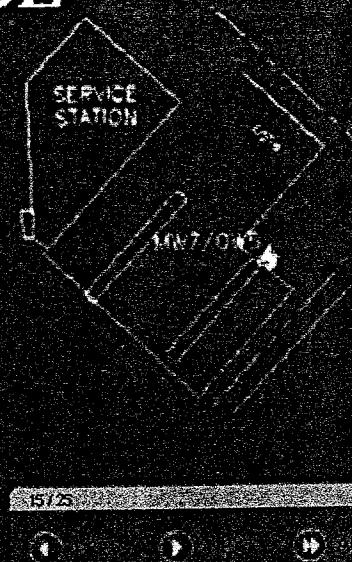
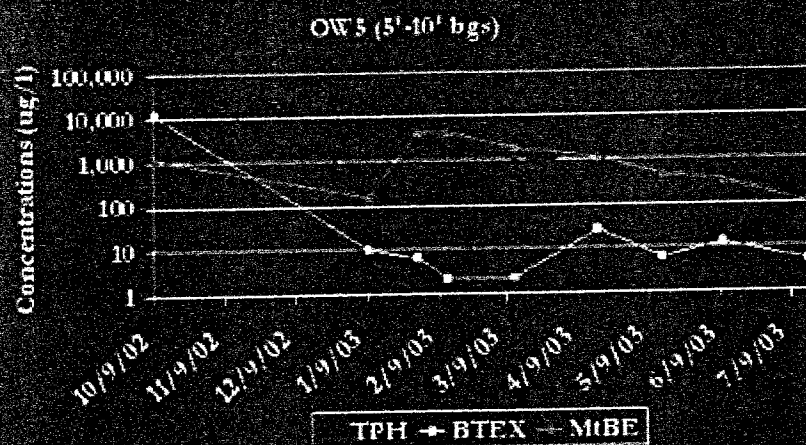
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TPH, Benzene, and MtBE in OW3 and MW6



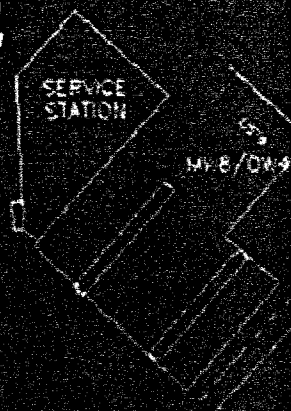
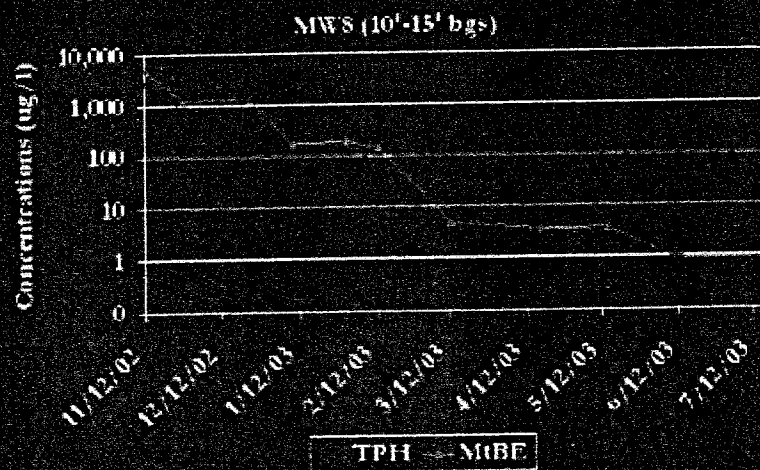
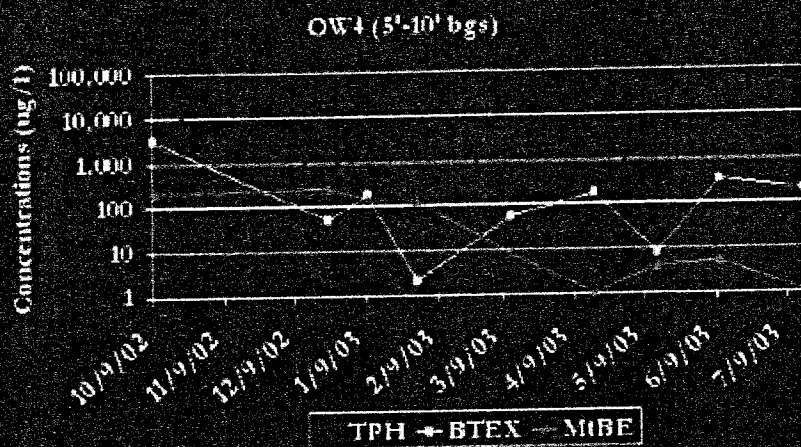
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TPH, Benzene, and MtBE in OW5 and MW7



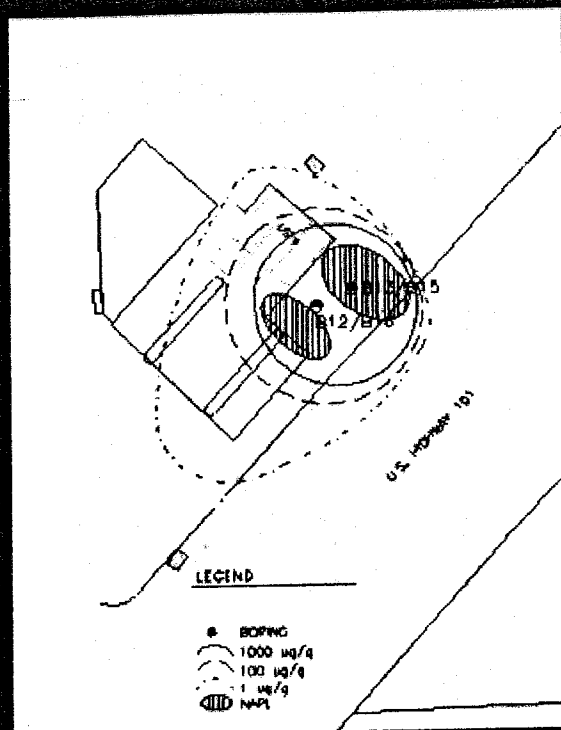
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TPH, Benzene, and MtBE in OW4 and MW8

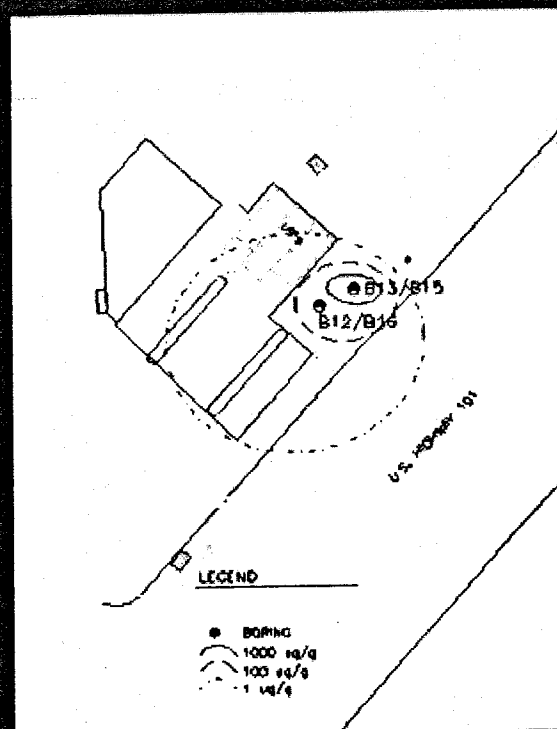


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Extent of Secondary Source



Pre-Treatment

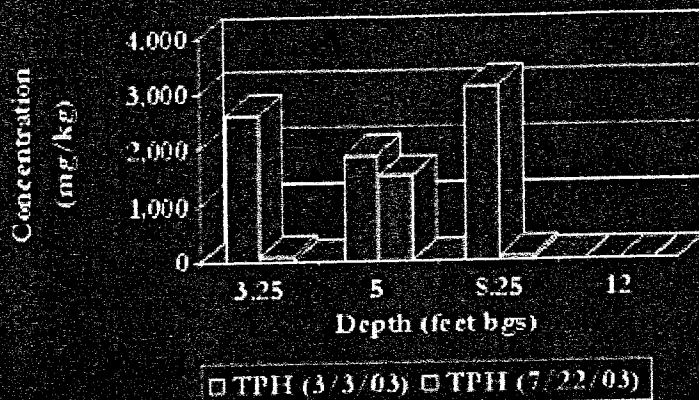


After 34 weeks of Treatment

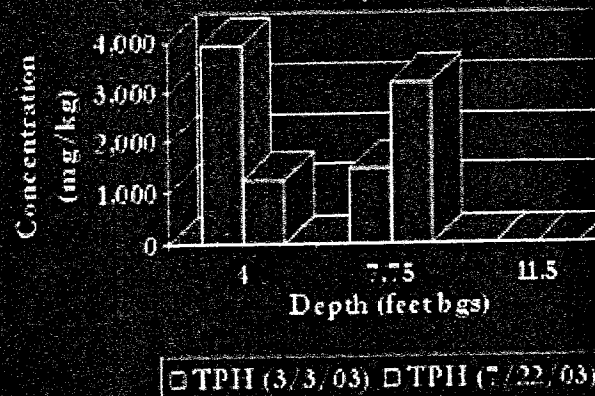
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Correlative Soil/Groundwater Results

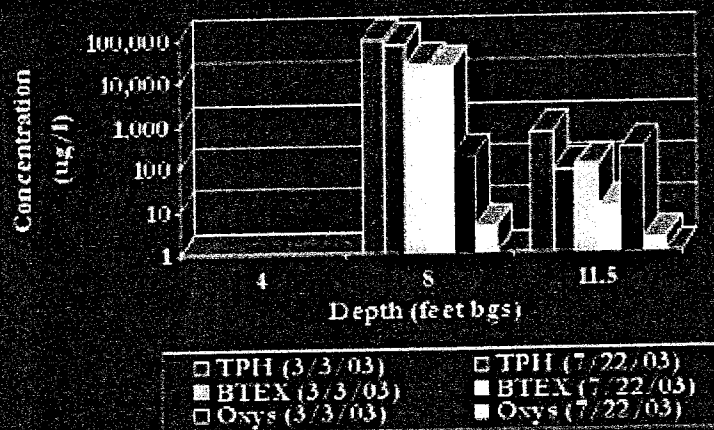
B12/B16 Soil



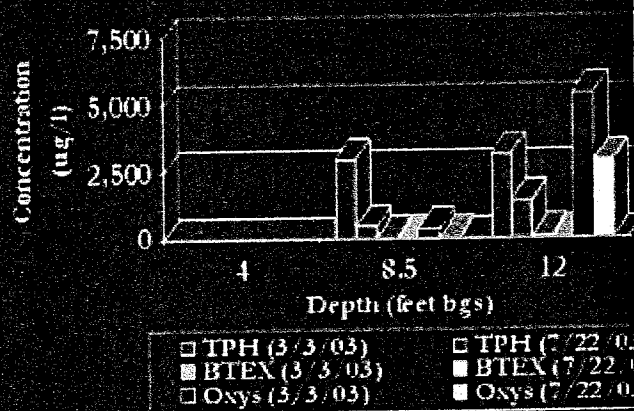
B13/B15 Soil



B12/B16 Groundwater

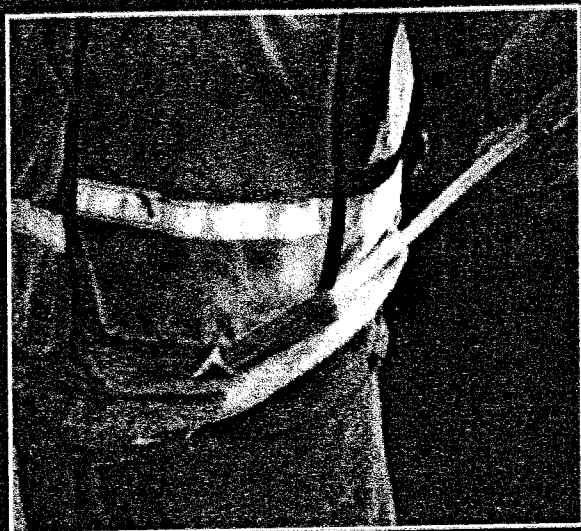


B13/B15 Groundwater



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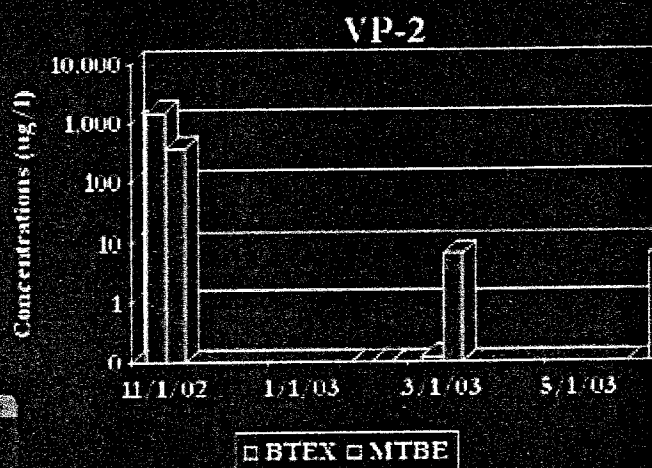
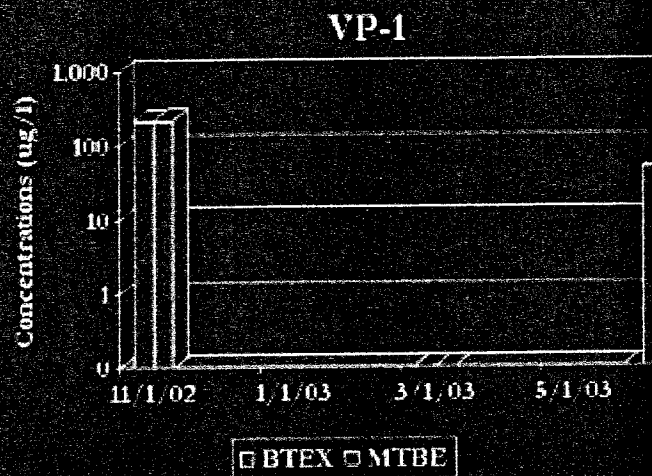
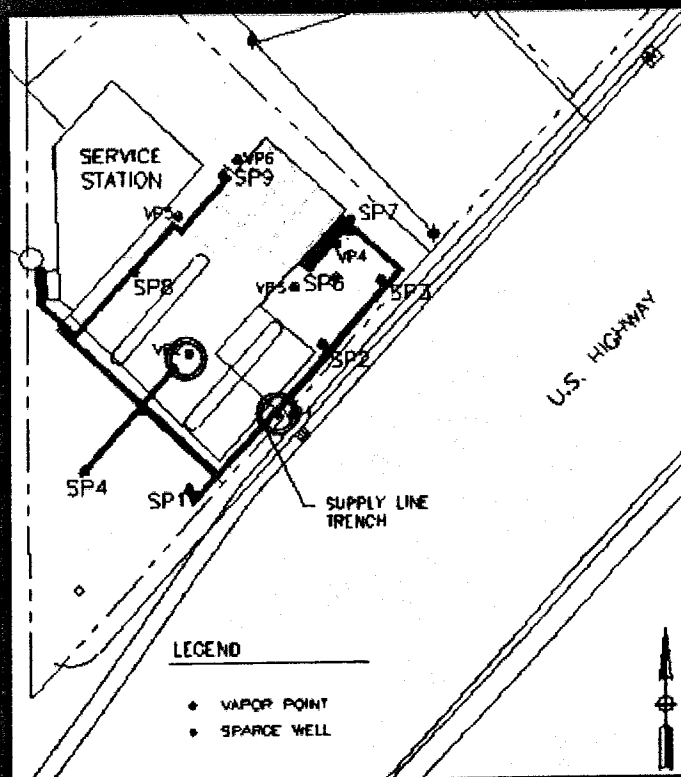
Vapor Monitoring Point Installation



Vapor points consist of soil gas probes with stainless mesh screens over the intake holes and Teflon collection tubes. Samples are collected with a peristaltic pump into Tedlar bags.

This presentation was converted by PowerPoint to Flash.

Results of Vapor Analyses



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Estimates of Mass Reduction

Initial mass estimates:

200 gal (750 L) NAPL

700 kg sorbed phase TPH

1.5 kg dissolved-phase BTEX

5 kg dissolved-phased MtBE

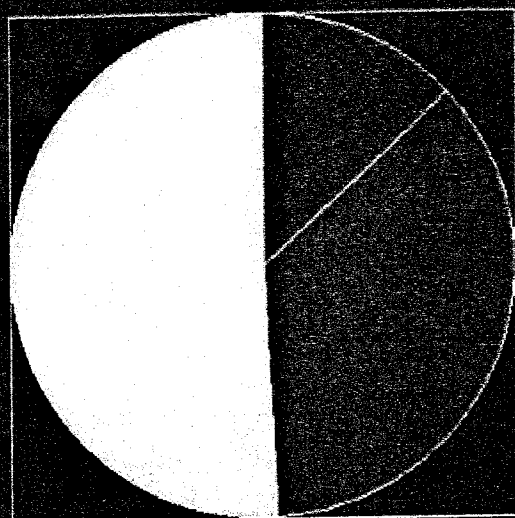
Results to date from monitoring wells and soil sampling indicate near to total reduction of NAPL and BTEX; reduction of MtBE by ~85%, or 4 kg; reduction of TPH by ~18%, or 90 kg.

Approximately 40 kg of ozone have been injected at an injection rate of 5g/hour for 7800 hours of operation to date.



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Balancing the Ozone Budget



- BTEX
- Fuel Oxygenates
- TPH + Oxidant Demand

Using the following ozone demand for contaminant degradation:

3.4 g ozone / g BTEX

3 g ozone / g MiBE

0.2 g ozone / g TPH

40 kg of ozone injected were spent on:

14 kg on fuel oxygenates

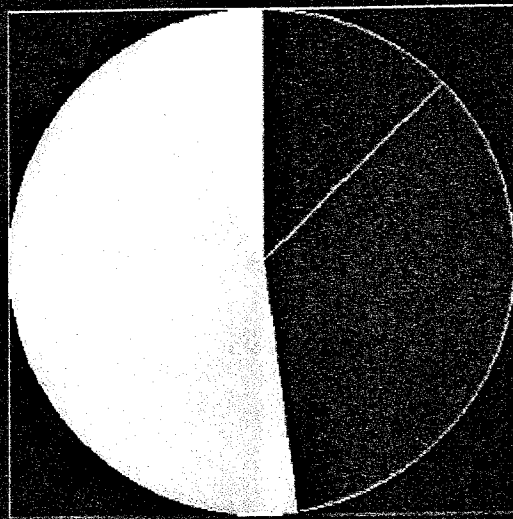
5 kg on BTEX

Balance of roughly 21 kg is available to meet TPH and background oxidant demands.



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Balancing the Ozone Budget (cont.)



- ☐ BTX
- ☐ Fuel Oxygenates
- ☐ TPH
- ☐ Background Oxidant Demand

90 kg TPH requires 18 kg ozone.

3 kg remains from budget for background oxidant demand.

Implications:

Soil oxidant demand not significant at low injection rates; TPH desorption begins when background groundwater oxidant demand met.



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Conclusions

At the apparent degradation rate of 90 kg in 20 weeks, we project that it will take approximately 3 years to degrade the estimated 700 kg secondary source.

It appears that at low injection rates (5 g/hr in this investigation) soil oxidant demand is not a significant consumer of ozone.

Further investigation needs to be performed on the relationship between high/low injection rates and soil/groundwater oxidant demands.

These results show that ozone sparging is very effective at remediating sorbed-phase petroleum hydrocarbons.



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ATTACHMENT C



iSOC® info

iSOC® YOUR ULTIMATE MANAGED ATTENUATION TOOL

iSOC® UPDATES

iSOC® has become a very popular bioremediation tool for remediating a wide range of contaminants, including recalcitrant compounds in groundwater and saturated porous media. iSOC® has already been used at hundreds of sites for effective hydrocarbon remediation, but we are continuing to improve and extend the technology.

A New Application of iSOC® Technology: Chlorinated Sites

Recently, iSOC® technology has been applied to sites contaminated with chlorinated hydrocarbons using oxygen and other gases to treat chlorinated sites under both anaerobic and aerobic conditions. Our website has been updated to reflect these bioremediation alternatives and various processes and soon our microcosm studies will provide more information to optimize delivery of combinations of gases to best stimulate the biological degradation of harmful substances.

A Micro-sized Control Panel

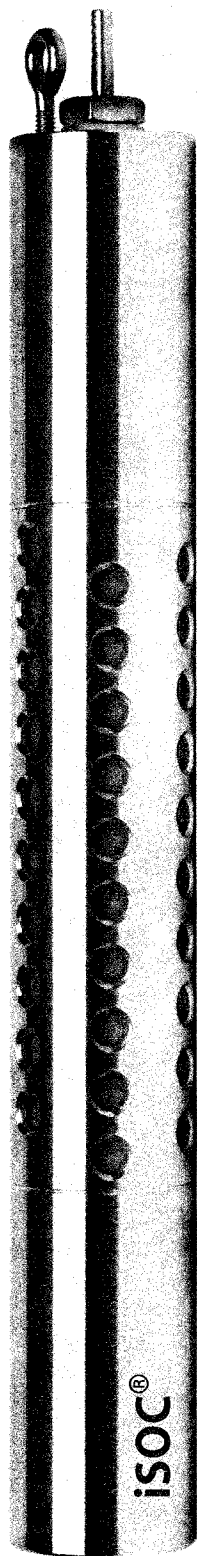
iSOC® is often used in individual wells with a small access box covering the well. While this set-up is cost-efficient and convenient, requiring no major site disruption or costly installation, the size of the access box is very limiting. Using innovative technology originally developed by NASA and successfully proven on our other Gas inFusion devices, we developed a small gas flow control device to sit in the top of the iSOC® unit. The result is a much simpler and easier installation that benefits the consultant and site owner both.

iSOC® AND BIOREMEDIATION ENHANCEMENT

iSOC® is an ingenious gas delivery system based on inVenture's patented Gas inFusion technology - a unique method of infusing supersaturated levels of dissolved gas into liquids. At the heart of iSOC®, the proprietary structured polymer mass transfer device is filled with micro-porous hollow fiber that provides an enormous surface area for mass transfer - in excess of 7000 m²/m³. It is hydrophobic and therefore excludes water. Maintaining gas pressure less than the surrounding liquid pressure ensures that ultra efficient mass transfer takes place without sparging.

In an aerobic bioremediation application, the iSOC® supersaturates the monitoring well with low decay dissolved oxygen (DO), typically 40-200 PPM depending on depth in groundwater. A natural convection current and a designed release bubble from the top of the iSOC® fills the well with a uniform DO curtain. The supersaturated DO curtain of water disperses around the well into the adjacent groundwater and enhanced bioremediation removes organics through natural attenuation. Placement of injection wells depends on site-specific conditions. The system is installed in a few hours and easily moved from well to well to optimize performance and remediation strategies.

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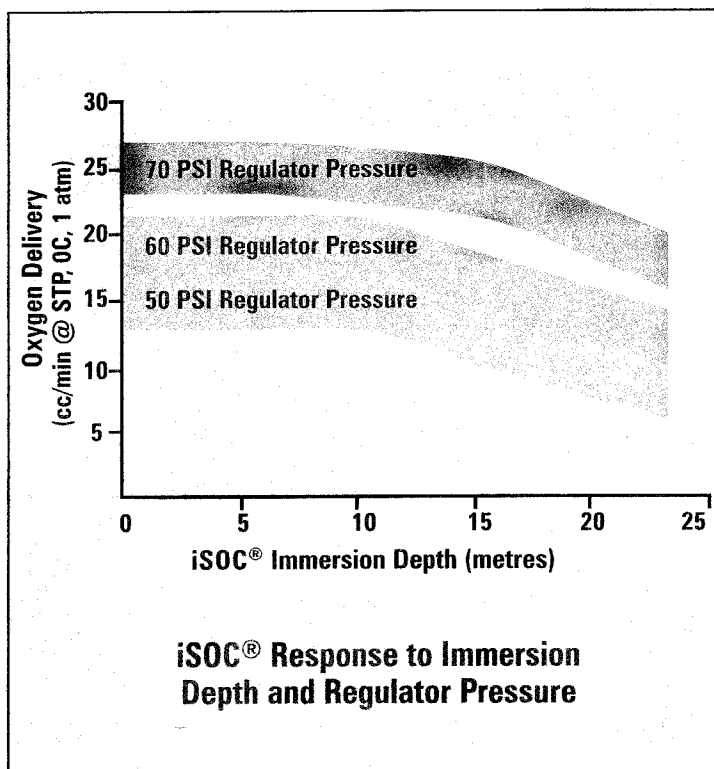
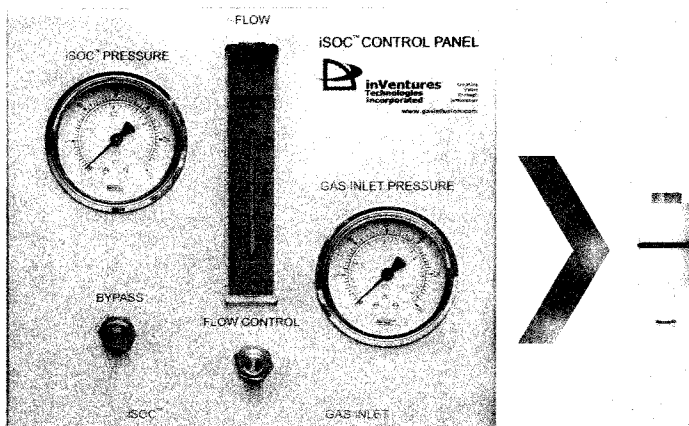


iSOC® ADVANTAGES

- Infuses 4 to 10 times more DO than any competitive technology.
- Delivers 40 to 200 PPM DO depending on iSOC® depth.
- Installs in existing 2-inch (50mm) monitoring wells.
- Application not limited by iron fouling under most conditions.
- Connects to standard gas cylinder.
- No power requirements, off-gases, pumps, or hazardous by-products.
- Small, simple, efficient, predictable, easy to use, & very low O&M.

MICRO-SIZING THE iSOC® CONTROL PANEL

In an effort to make the iSOC® System as easy to deploy as possible, the iSOC® Control Panel which determined the gas flow to the iSOC® and its structured polymer mass transfer device has been micro-sized. It now sits within the top of the iSOC® device and automatically controls the gas flow depending on groundwater depth and pressure regulator setting. All the installer has to do is set the pressure on the two-stage regulator. The iSOC® is simply attached to the tubing from the iSOC® Distribution Header and lowered into the well. There is no longer any need to house and mount a bulky control panel. The micro-sized flow controller is based upon valve control technology initially used in the NASA Space program and currently used on other Gas inFusion Technology applications.



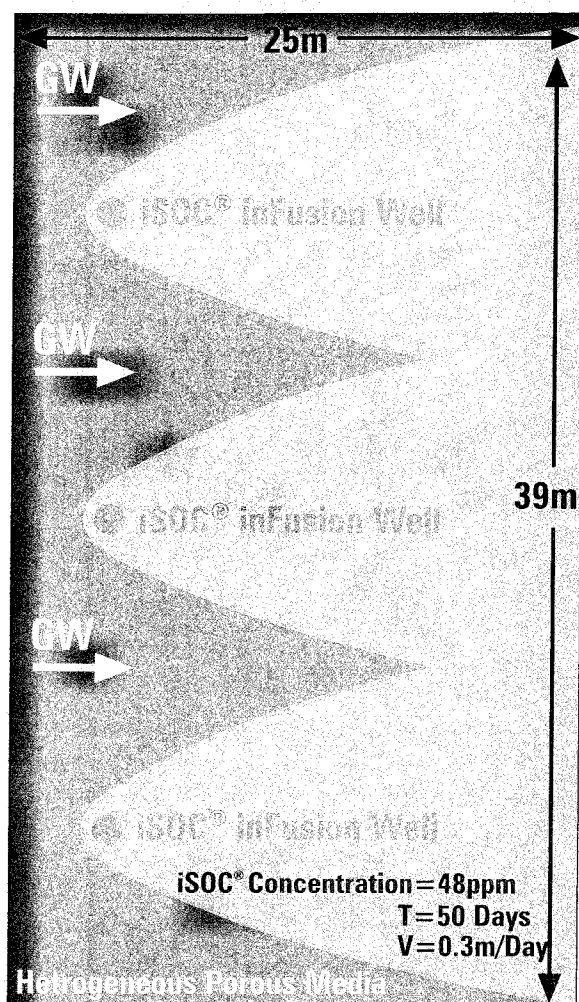
MICRO-FLOW CONTROLLER

The built-in flow controller delivers a range of oxygen flow to the mass transfer device within the iSOC® depending on the immersion depth in groundwater and the pressure regulator setting. For immersion depths of less than 60 feet (18.3 m) of water, it is recommended that the oxygen regulator be set at 50 psi (3.4 bar). This will result in an average of 15 standard cc/min of oxygen delivered to the groundwater by the iSOC®. For greater depths, the regulator setting should be adjusted such that it is a minimum of 25 psi (1.7 bar) above the head pressure of the water.

WHERE HAS iSOC® BEEN USED?

The iSOC® technology has been used at hundreds of sites in the US, Canada, UK, Europe and Africa. It is currently being piloted on sites in Australasia and Japan. The technology has been deployed to bioremediate a range of hydrocarbons and other chemicals using direct aerobic, cometabolic, and anaerobic degradation methods.

iSOC® CONES OF INFLUENCE BASED ON FEMLAB MODEL



iSOC® REMEDIATION APPROACH

- Create an oxygen barrier at the leading edge of the contaminant plume to avoid boundary litigation and to protect off-site receptors.
- Reduce contamination levels by source treatment with supersaturated oxygen at the heart of the plume.
- Achieve rapid, localized remediation of low-level contamination and hot spots in existing monitoring wells.
- Accelerate site closure through natural attenuation as a primary remediation strategy or as a polisher.
- Lowest annual O&M cost of any passive enhancement technology.

HYDROCARBONS AND iSOC®

The use of dissolved oxygen in hydrocarbon-contaminated groundwater to enhance natural attenuation of hydrocarbons such as MTBE and BTEX has been growing as a remediation technology since the mid-1990s. Conventional sparging technologies typically waste most of their delivered oxygen. Sparging bubbles make preferential flow paths and rise to the top of the groundwater table, escaping before they have a chance to dissolve and be utilized by naturally occurring hydrocarbon-degrading micro-organisms. Other in-situ technologies generate oxygen for a short period of time but are inadequate in aquifers with high ferrous iron, moderate BOD, and/or high concentrations of hydrocarbon constituents. iSOC® is a proven bioremediation technology that delivers high concentrations of dissolved oxygen into the aquifer. Very low O&M costs allow the iSOC® technology to be deployed in all types of remediation projects and site conditions.

iSOC® RADIUS OF INFLUENCE

Case studies and field measurements have shown the typical iSOC® radius of influence to be 10 feet (3 m) to 20 feet (6 m) laterally from the infusion well and many more feet in the direction of groundwater flow. Flowing groundwater and molecular diffusion transport the dissolved gas (e.g. oxygen, alkane, hydrogen) to the saturated porous media. The higher the concentration in the infusion well, the further the transport of the gas and the greater the influence. The influence is best measured by biological parameters, as the measure of dissolved gases at a distance from the infusion well is often inconclusive.

TYPICAL GAS CONCENTRATIONS (ppm)

GAS TYPE	WATER COLUMN DEPTH (ft/m)				
	5'/1.5	10'/3	15'/4.6	20'/6.1	50'/15.2
Oxygen	42	55	62	69	111
Methane	22	30	33	37	59
Propane	66	88	99	110	175
Hydrogen	2	2	3	3	5
Ethane	57	75	85	95	150

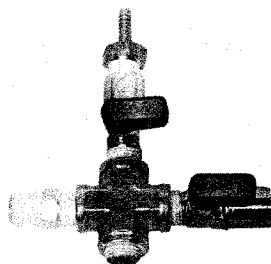
USING OTHER GASES WITH iSOC®

Consultants may need to use gases other than oxygen in their remediation approach. For example, hydrogen, methane, or propane may be used for remediation of chlorinated solvents and perchlorate. iSOC® will transfer these gases into the groundwater as effectively as it transfers oxygen, as shown above.



iSOC[®] info

iSOC[®] YOUR ULTIMATE MANAGED ATTENUATION TOOL



iSOC[®] DISTRIBUTION HEADER

Each order is supplied with a distribution header. Multiple port distribution headers are available. The size ordered is determined by the number of iSOC[®] units being run from each regulator. The distribution header can be directly mounted onto the gas regulator. The header is supplied with an on/off valve for each iSOC[®] unit such that the gas bottles can be changed without pulling the iSOC[®] from the well. For further detail go to www.isocinfo.com - Installation and Design - Installation Procedures.

iSOC[®] QUALITY CONSTRUCTION

iSOC[®] is constructed of high quality SS316 stainless steel using the latest manufacturing equipment and a proprietary structured polymer mass transfer device. iSOC[®] is 1.62" (41 mm) in diameter and 12.65" (321 mm) long with a barb connector for 0.17" (4 mm) ID polyurethane tubing. The housings for the pressure and flow control unit and the drain plug are made from nylon. iSOC[®] has a lifting ring for connecting to a suspension line for insertion in 2" (50 mm) or larger monitoring wells.

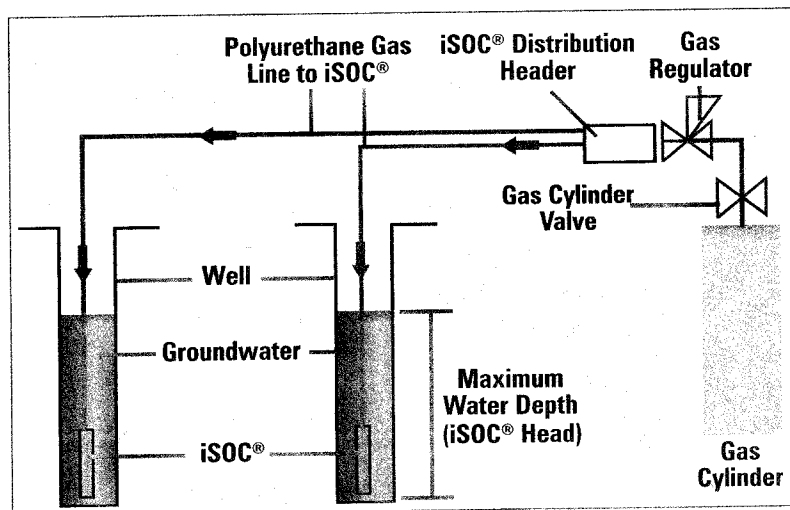
iSOC[®] COSTS

The iSOC[®] groundwater remediation technology is the leading and most cost effective solution in the marketplace today. Speak with your local iSOC[®] Sales Representative for system pricing. Your nearest Sales Representative can be found at www.isocinfo.com

CHLORINATED SOLVENTS AND iSOC[®]

The iSOC[®] Gas inFusion system is used to effectively remediate chlorinated solvent contaminated groundwater. Where tetrachloroethene (PCE) is the main contaminant of concern, a two-stage sequential bioremediation approach is used to first degrade PCE to trichloroethene (TCE) by reductive dechlorination, followed by aerobic cometabolic oxidation of TCE and other daughter products such as DCE and vinyl chloride. Alkane gas delivered by iSOC[®] stimulates the anaerobic process. iSOC[®]s are used to deliver oxygen and additional alkane gas to achieve aerobic cometabolic treatment of the daughter products. The aerobic process can be applied independently to TCE, DCE and VC sites and is not subject to stall due to competing electron acceptors or limited availability of necessary anaerobic microorganisms. Several alternative bioremediation approaches can also be implemented with iSOC[®]s including direct aerobic treatment of vinyl chloride and reductive dechlorination of chlorinated solvents by direct hydrogen delivery.

SYSTEM SET-UP



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**iSOC[®] info**

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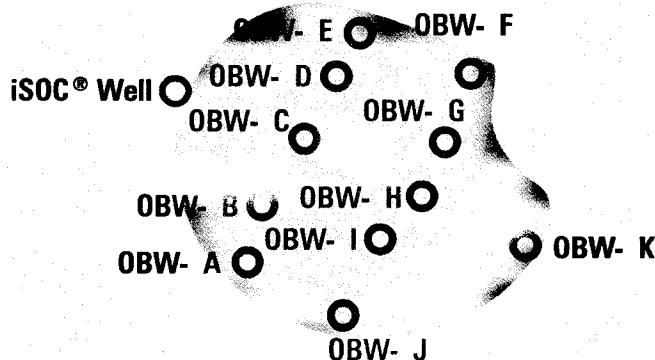
PILOT CASE STUDY: GROUNDWATER BIOREMEDIATION OF A RAILROAD XYLENE SPILL NORTHERN GEORGIA

A spill of approximately 50,000 gallons of pure xylene occurred as a result of a train derailment in north central Georgia in 1988. The spill resulted in two separate xylene plumes in the groundwater. Heterogeneous layers of interbedded sands, silts and silty clays underlie the site. Most of the site can be characterized as having low permeability. Depth to bedrock at the site is generally at 7 to 15 feet.

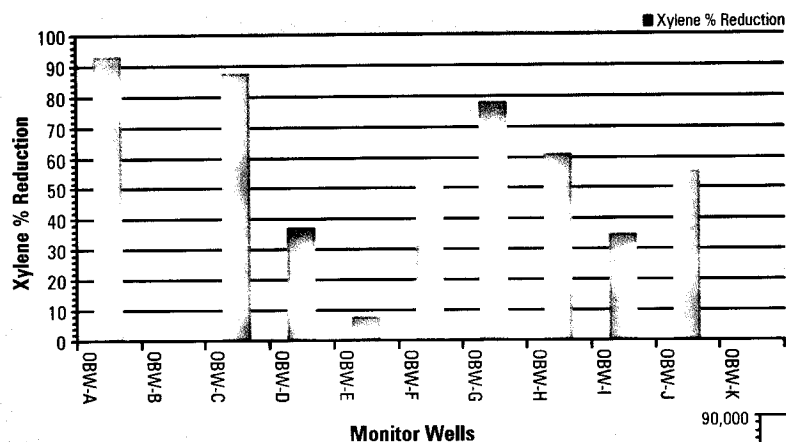
Groundwater remediation at the site was initially accomplished using a biosparging/soil vapor extraction system. In an effort to reduce capital and O&M costs, the site consultant began a pilot test in April 2004 using the iSOC[®] technology. This system is particularly successful in low permeability sites. The pilot test was initiated in one of the xylene plumes referred to as the south plume. This plume is approximately 500 feet long and 80 feet wide, has xylene concentrations ranging up to 180,000 ppb, and is moving in a southerly direction toward a creek. The pore velocity of the groundwater is 78 ft/year though the xylene is moving slower. One iSOC[®] injection well was installed in groundwater with xylene concentrations up to 82,000 ppb. To measure changes in groundwater quality downgradient from the injection well, 11 observation wells were installed in lines perpendicular to groundwater flow at distances of 10, 20, and 30 feet from the injection well. The first two rows had 5 monitor wells spaced 5 feet apart. BTEX and heterotrophic bacteria plate counts were measured.

Site analysis has shown that there was iSOC[®] influence in each of the 11 monitoring wells down gradient of the injection well (IN-1) within only one month of pilot startup. Within this area of influence and within one month of pilot startup, each of the 11 monitor wells down gradient of the injection well showed substantial increase in heterotrophic bacteria colonies. This area of influence has a minimum width of 20 feet and minimum length of 30 feet down gradient of the single iSOC[®] injection well. Four months after pilot startup, xylene has been reduced in a total of 9 of 11 monitor wells in the study area. Within the first 20 feet down gradient of the iSOC[®] well, xylene concentrations have been reduced by an average of 57% in 9 of 10 wells. A full scale system is planned.

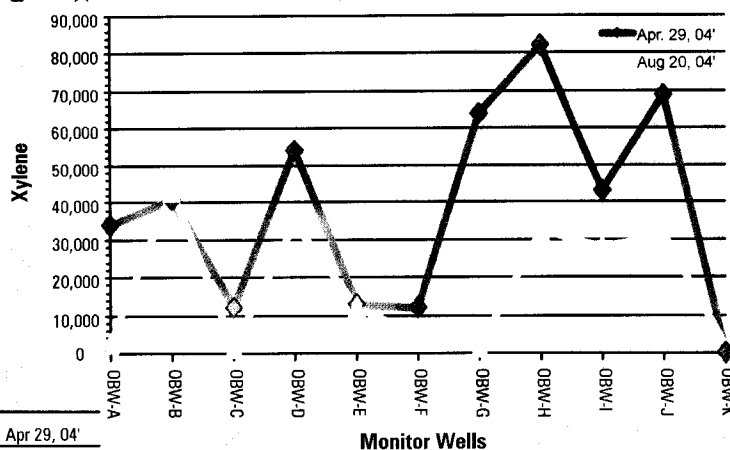
PILOT LAYOUT



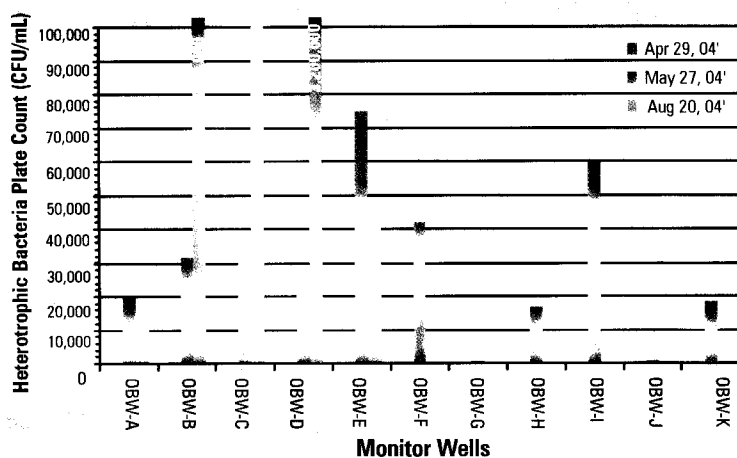
XYLENE PERCENTAGE REDUCTION



XYLENE PLOT



HETEROTROPHIC BACTERIA PLATE COUNT (CFU/mL)



iSOC® AND BIOREMEDIATION ENHANCEMENT

iSOC® is an ingenious gas delivery system based on inVenture's patented Gas inFusion technology - a unique method of infusing supersaturated levels of dissolved gas into liquids. At the heart of iSOC®, the proprietary structured polymer mass transfer device is filled with micro-porous hollow fiber that provides an enormous surface area for mass transfer - in excess of 7000 m²/m³. It is hydrophobic and therefore excludes water. Maintaining gas pressure less than the surrounding liquid pressure ensures that ultra efficient mass transfer takes place without sparging.

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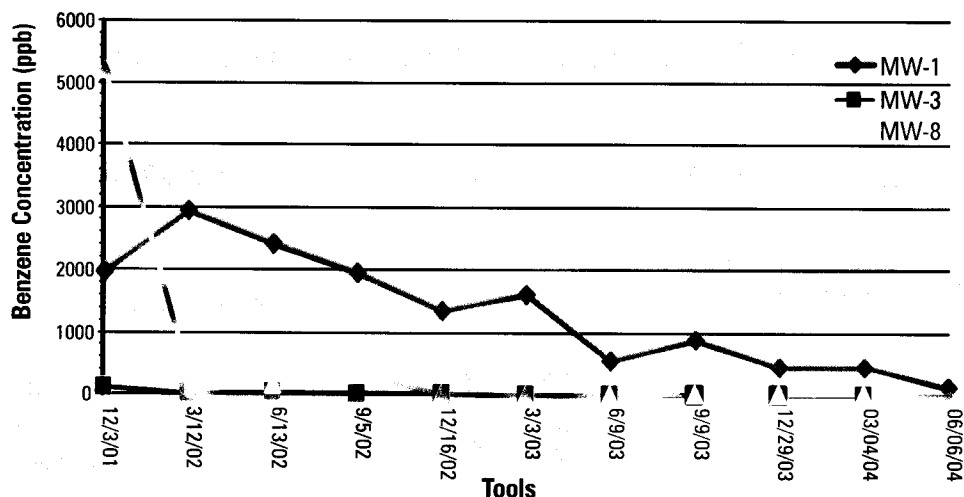
PILOT CASE STUDY: ENHANCED NATURAL ATTENUATION OF MTBE, BENZENE AT A LOW PERMEABILITY COLORADO SITE

iSOC® CASE STUDY: ENGLEWOOD, CO

- Low permeability silty clay sediments (permeability between 10^{-4} and 10^{-6} cm/sec).
- Gradient of 0.04 with groundwater flow to the NE.
- BTESite depth to water table approx. 20 ft.
- DO disperses around well into groundwater.
- Benzene primary concern at site from mid 90's to Dec. 01'. MTBE sampled at site Dec. 01', found concentrations as high as 195,000 ppb.

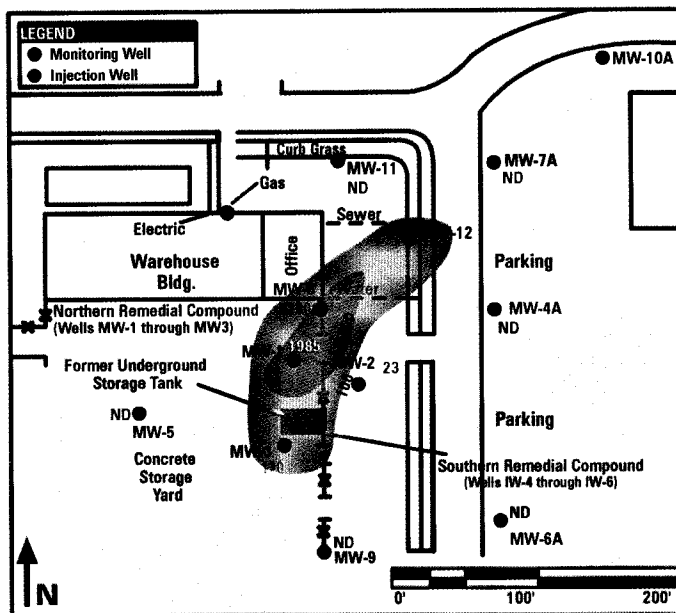
HISTORY OF SITE - REMEDIATION

- Tanks pulled in mid 90s.
 - Extensive amount of contaminated soil removed (no new tank installed).
- Sparge System Operated May 95 - Sept 96.
 - Very ineffective. Spread large amount of BTEX down gradient, cross gradient.
- Site Groundwater Monitoring.
 - Biannual 1996 – 2000.
 - Quarterly 2001 to present.
- iSOC® Technology
 - Pilot with one iSOC® near MW-8, Jan 02 – July 02. Additional 5 iSOC®s installed, Aug 02 - present.

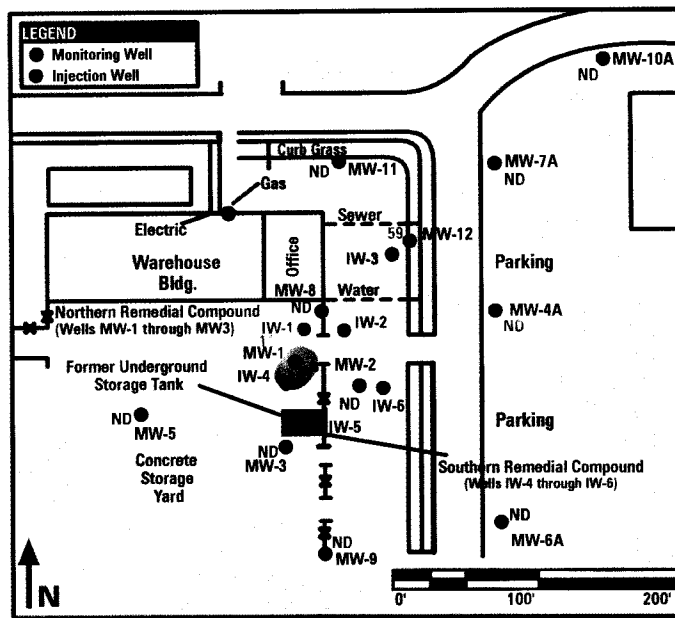


**REMEDICATION RESULTS:
BENZENE RESULTS**

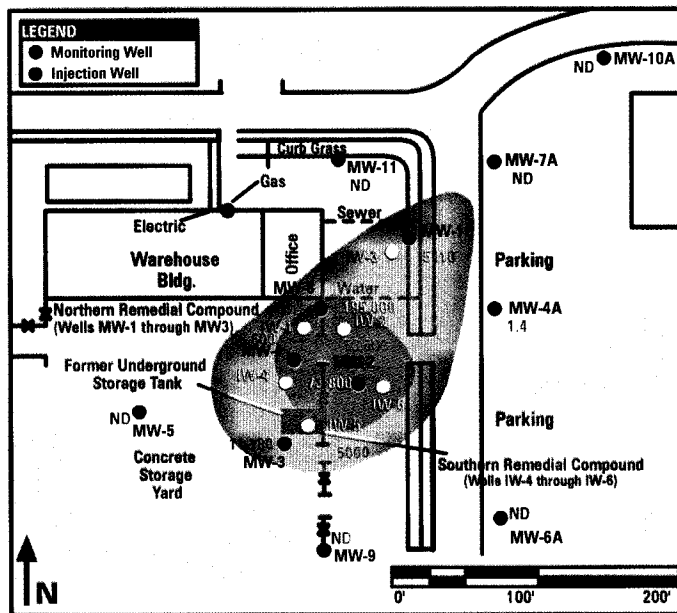
BENZENE CONCENTRATION: DEC 2001



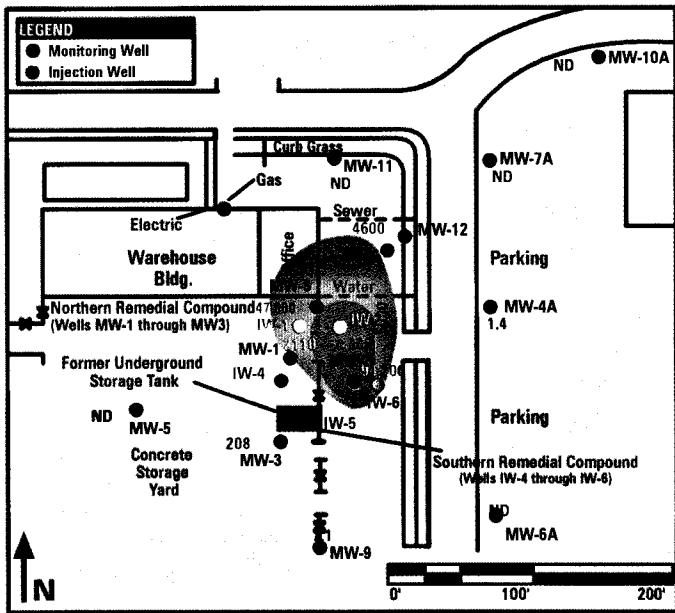
BENZENE CONCENTRATION: JUN 2004



MTBE CONCENTRATION: DEC 2001



MTBE CONCENTRATION: JUN 2004



CONCLUSION

- The iSOC® system was successful in stimulating attenuation of the MTBE and benzene hot spot.
- Contaminant migration was limited.
- Benzene concentrations reduced up to 99%.
- MTBE concentrations reduced significantly but still fluctuating.
- System continuing to operate to attenuate "rebound" increases in MTBE and benzene in the core of the hot spot.
- Use of iSOC® in low permeability sites provides cost benefit over site monitoring only option.



iSOC[®]

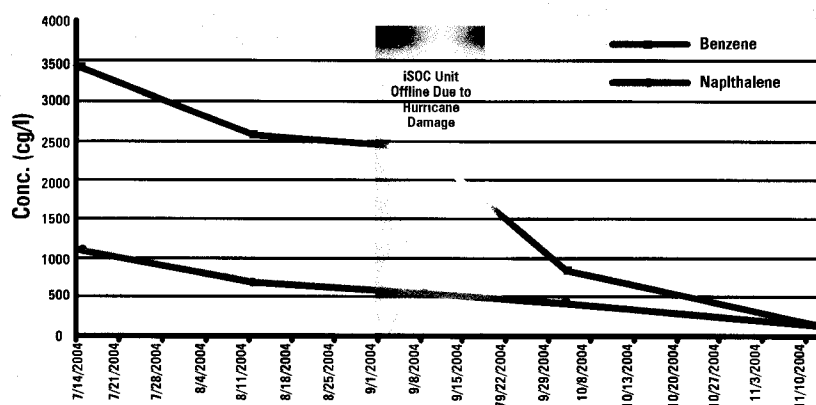
iSOC[®] YOUR ULTIMATE MANAGED ATTENUATION TOOL

CASE STUDY: MANUFACTURED GAS PLANT

PROBLEM

- Primary remediation – Excavation and ISS
- Residual source material at the edge of stabilized material.
- Regulators forced installation of monitoring well in close proximity to ISS (in-situ solidified) material.
- Offsite wells clean.
- MNA trend in onsite well is upward.
- Interbedded clays and sands prevent sparging.

PILOT CELL RESULTS: MW 101

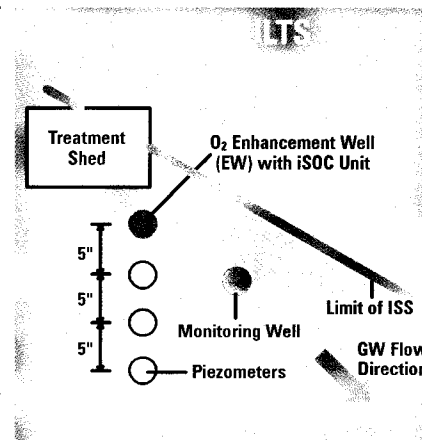


IN-SITU OPTIONS

- Chemical Oxidation
- Enhanced Bioremediation
- Chem-Ox ruled out due to cost and uncertainty.
- Enhanced Bio was determined to be the cheapest alternative.
- Original enhanced bio pilot proposed ORC slurry injected into treatment zone but was considered labor intensive and expensive.

PILOT DESIGN

- iSOC[®] Gas inFusion system using O₂ selected as economical and effective.
- Pilot cell located at historically impacted well.
- Pilot duration - 6-months
- Monitor O₂ levels in wells and piezometers. Measure COI (Constituents of Interest) change in monitoring well.

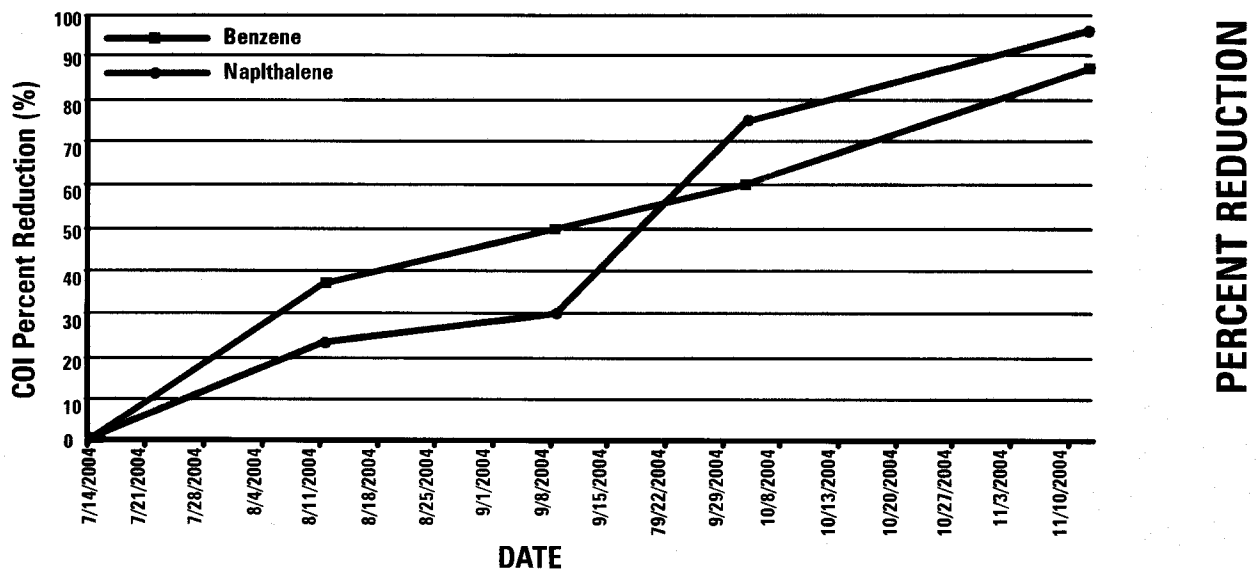


iSOC[®]

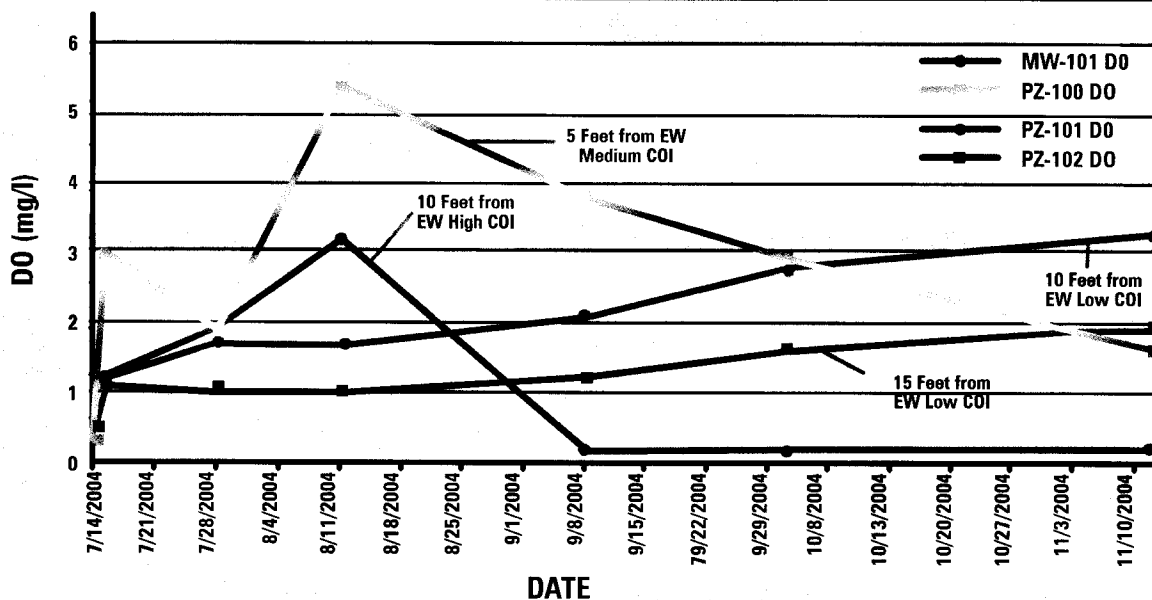
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O & M

- Long term O&M is favorable versus ORC and air sparging.
- To date pilot has cost \$36 in oxygen and O₂ tank rental.
- On a separate site RETEC is currently designing a 24 unit iSOC® system, O&M with iSOC® using O₂ is estimated at \$30K/year.
- Same site, ORC O&M estimated at \$60-80K/year and air sparging at \$30-50K per year each with significant upfront capital costs.



DO TREND



CONCLUSION

- Enhanced Bioremediation has been successful in controlling GW COI levels.
- One of the first MGP sites in the nation to use O₂ infusion with iSOC®.
- Combination of low O&M cost and effectiveness provides many benefits over other forms of O₂ delivery.
- Next step is installation of full scale treatment wall.



iSOC

iSOC® YOUR ULTIMATE MANAGED ATTENUATION TOOL

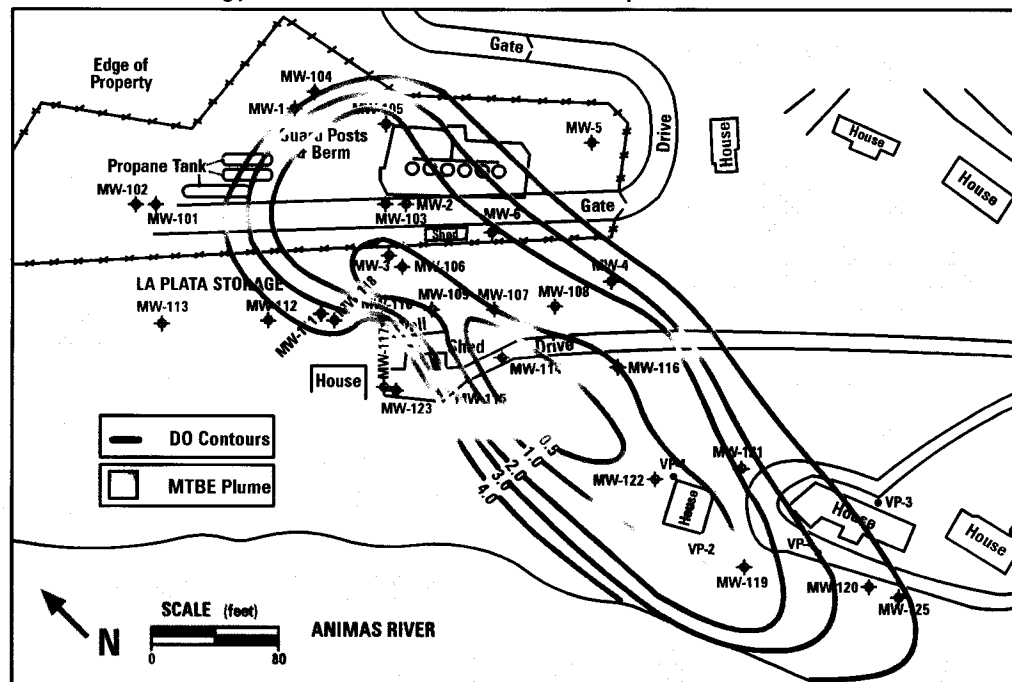
PILOT CASE STUDY: REMEDIATION OF RESIDUAL MTBE IN A FRACTURED BEDROCK AQUIFER IN SOUTHWESTERN COLORADO

SITE BACKGROUND

- Bulk petroleum storage facility with release of gasoline.
- Remedial investigation began Summer, 2002.
- BTEX and MTBE found in ground water on- and off-site.
- Direction of ground water flow is due south toward Animas River.
- Contamination found in fractured bedrock aquifer underlying site and outcropping along Animas River.
- Major concern: petroleum constituents reaching Animas River.

CLEAN-UP STRATEGY

- Soil vapor extraction system installed on-site and immediately off-site.
- SVE successful at removing majority of petroleum contamination.
- Major concern: Residual ground water contamination plume of mobile MTBE 320' long by 40' wide in fractured bedrock moving toward the Animas River.
- MTBE concentrations in plume: 59ppb to 6 ppb.
- iSOC® technology chosen to remediate the MTBE plume.



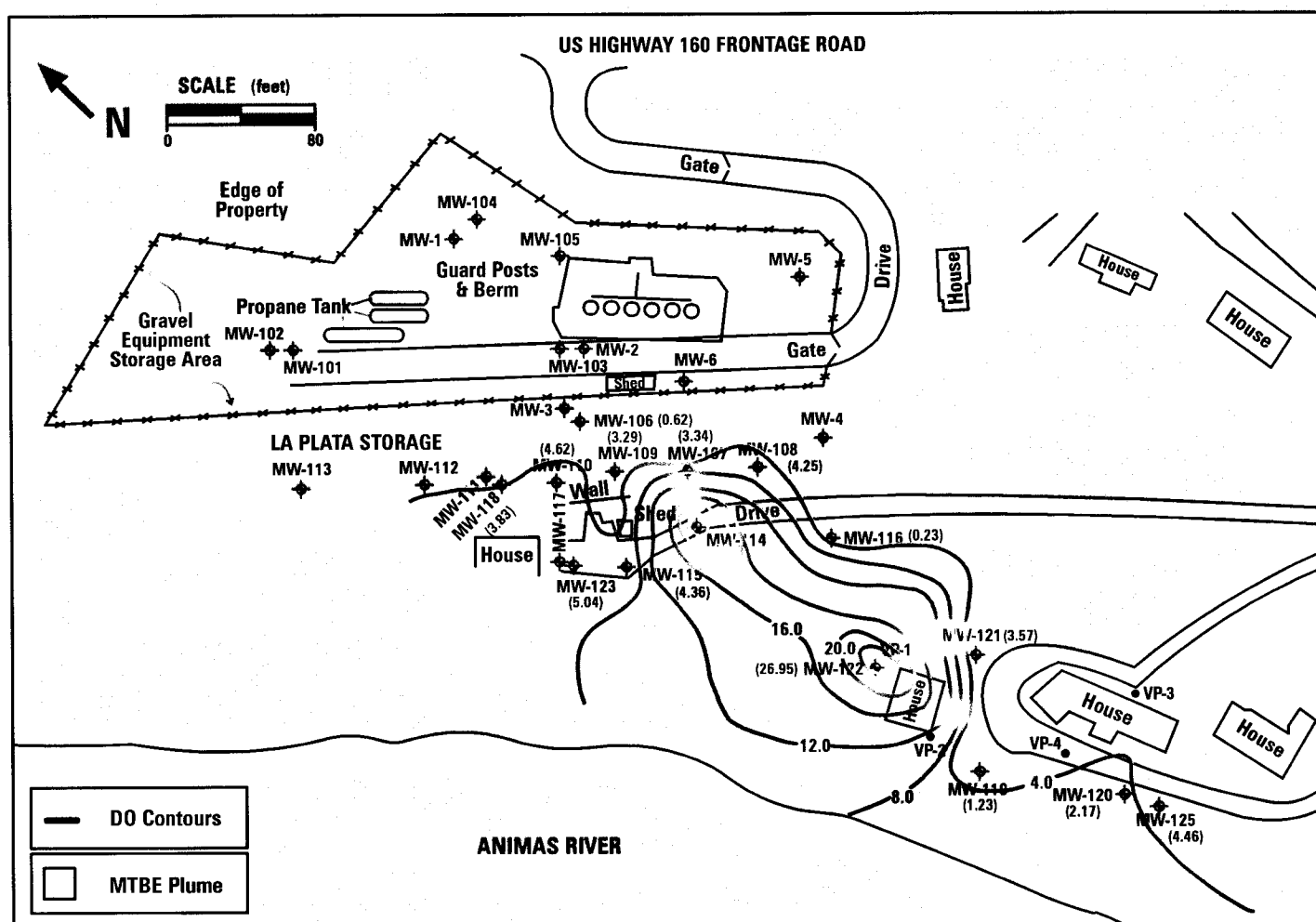
PRE - iSOC® DISSOLVED OXYGEN
CONTOURS (ppm)

iSOC®

iSOC® REMEDIATION PLAN

- June, 2004: 2 iSOC® units installed in 2 existing bedrock monitor wells (MW-122, MW-114) in the MTBE plume.
- Each well has water column of approximately 10'.
- Prior to iSOC® startup, dissolved oxygen (DO) levels in MTBE plume < 1ppm.
- June 2004-Feb 2005: iSOC® system running 8 months. DO increased throughout contamination area.
- DO in injection wells maintained at approximately 27 ppm.
- Feb 2005: DO up to 4 ppm in monitor wells at distances of 60-80' from MW-114.
- Feb 2005: DO up to 4 ppm in monitor wells at distances of 100 -160' from MW-122.

DISSOLVED OXYGEN CONTOURS AT 8 MONTHS (ppm)



SITE CLOSURE

- After two rounds of quarterly ground water sampling, MTBE concentrations in all off-site wells below detection limit.
- Feb 2005: iSOC® system removed from site and will be deployed at another site.
- This site currently in post-remediation monitoring.

cl solutions

Bringing Bioremediation Up To Speed

For more information contact:

Michelle Broyles

CL-Solutions

100 Industrial Drive

Cold Spring, KY 41076

mlb@cl-solutions.com

877-257-6588

FOR IMMEDIATE RELEASE

CL-SOLUTIONS OFFERS RAPID AEROBIC BIOREMEDIATION FOR HYDROCARBON CONTAMINANTS

Petrox™ Field-Proven To Close Sites Quickly, Often In Less Than 90 Days

(COLD SPRING, KY) – Commonly used at fuel terminals and gas stations, in the metals and chemicals industries, citrus production, railroads, manufactured gas plants, and wood treatment facilities, Petrox™ from CL-Solutions has been shown to deliver active, rapid aerobic bioremediation of environmental contamination caused by petroleum hydrocarbons, organic solvents, and semi-volatile hydrocarbons.

The product contains highly-concentrated solutions of live patented strains of lyophilized (freeze-dried) microscopic organisms (microbes) that occur naturally in the earth's ecosystem. Extracted from a once-contaminated site and isolated under controlled laboratory conditions, these "hungry bacteria®" have only one purpose in life: to seek and destroy contamination at its source, and then quickly convert it into harmless, naturally recyclable by-products. Available in three standard blends or custom formulated for specific needs, Petrox can be used as a highly effective stand-alone decontamination solution for new sites, or as a powerful augmentation to speed the remediation of existing sites. Because of its faster than average cleanup rates, Petrox remains remarkably affordable, making property redevelopment feasible for any contaminated site, industrial or commercial.

"Bioremediation helps property owners take advantage of those natural microbes that may already exist at their site," said company Vice-President Mike Saul. "Easy to apply inoculations of Petrox boost the population of microbes in areas designated to be reclaimed by adding billions of these microbes to the existing population, and thereby "speeding up the processes of nature."

The product has been shown to effectively remediate gasoline, diesel and heating fuels, BTEX compounds, MEK, methylene chloride, and naphthalene (Blend #1); terpene-based solvents (Blend #2); anthracene, creosote, chlorotoluene, chrysene, cresols, pentachlorophenol, phenanthrene, as well as the pesticides 2,4-D, Endrin, and Aldrin (Blend #3). Petrox is available as a freeze-dried powder or as a concentrated liquid.

A leader in the field of bioremediation, CL Solutions rapidly and affordably bioremediates soil and groundwater contaminated with hydrocarbons and chlorinated solvents. The company's products, CL-Out™ and Petrox™, have been field-proven to work faster, work better, and cost less than other hazardous waste cleanup solutions. For more information, visit their new website at <http://www.cl-solutions.com>.

100 Industrial Road
Cold Spring, KY 41076
859-442-8590

MATERIAL SAFETY DATA SHEET

Prepared: 01/01/01
Supersedes: 10/27/00

N.A.: Does Not Apply
N.K.: Not Known

Section I

Product Identification

Manufacturer's Name: **CL Solutions**
Emergency Telephone Number: 1-859-442-8590
Address: 200 Industrial Rd., Cold Spring, KY 41076

Chemical Name: Bacterial Inoculant for Petroleum Hydrocarbon remediation.
Trade Name: **PETROX**

Microbial Formulation: The product formulation consists of naturally occurring microorganisms.

Section II

Hazardous Ingredients

Proprietary Blend of Inorganic Salts More than 1%

Section III

Physical Data

Boiling Point (°F)	N.A.
Specific Gravity	2.26
Vapor Density (Air = 1.0)	2.9
Percent Volatile by volume (%)	N.A.
Evaporation Rate	N.K.
Solubility in water	Soluble
Appearance and Odor	White to off white powder/No Odor.

Section IV

Fire and Explosion Hazard Data

Flash Point (Method Used)	N.A.		
Flammable Limits LEL	N.A.	UEL	N.A.
Extinguishing Media	Water, Fog, Foam		
Special Fire Fighting Procedures	None		
Unusual Fire and Explosion Hazard	Stable below 1000°F. Use NIOSH/OSHA approved pressure self-contained breathing apparatus when material is involved in fire.		

Section V

Health Hazard Data

Toxicology

Acute Studies

* Rat oral LD₅₀ is greater than 5 g/Kg of body weight; as evidenced by no observed mortality after rats were dosed with 5 g/Kg at a concentration of 500 mg PETROX/ml of water and a dose volume of 10 ml/Kg of body weight.

* Rabbit dermal LD₅₀ is greater than 2 g/Kg of body weight; as evidenced by no observed mortality after rabbits were exposed to the test material applied to abraded and non-abraded occluded skin for 24 hours. No severe dermal effects were reported at the dose site.

* Eye irritation in rabbits was reported as slight. Highest observed scores out of a possible score of 110 were:

1 hour: 12; 24 hours: 8; 48 hours: 4; 72 hours: 4; 4 days: 2; 7 days: 2;
10 days: 2; 14 days: 2.

* Rat inhalation of the test material at an average analytical exposure concentration of 1.2 mg/l of PETROX (nominal concentration of 37 mg/l) for 6 hours produced no mortality. Approximately 40% of the dust was less than 10 microns in size.

Chronic Health Hazards

* Although chronic studies using PETROX are not available, inhalation of this product should be prevented, due to unknown long-term effects.

Special Notes:

Not for human and animal consumption.

Emergency First Aid Procedures

Eye Contact	Flush eyes with sterile water until irritation subsides or stops.
Skin contact	Wash with soap and water.
Inhalation	Although not an acute hazard as tested in rats, product is respirable and chronic effects are unknown. Upon prolonged or repeated respiratory contact, see a physician.
Ingestion	Low order of toxicity. Upon ingestion, induce vomiting and contact a physician.

Section VI**Reactivity Data**

Stability	Stable
Incompatibility (Material to avoid)	N.K.
Hazardous Decomposition Products	This product does not undergo spontaneous decomposition. Typical combustion products are carbon, carbon dioxide, nitrogen and water.
Hazardous Polymerization	Will not occur.

Section VII**Spill or Leak Procedures**

Steps to be taken in case material is released or spilled.	No Hazard. Wash away with plenty of water.
Waste Disposal Method	Use normal solid waste methods in conformance with pertinent federal, state, and local regulations.

Section VIII**Special Protection Information**

General Precautions	Treat as you would any chemical or biological material. Always wash hands thoroughly after use.
Respiratory Protection	Use Paper or Cloth mask.
Ventilation	Material should be handled in a manner that will minimize dusting.
Eye Protection	Use Safety Goggles.
Special Precautions	This product is not intended for human or animal consumption.

Section IX**Additional Information****Contact**

John Morris
Managing Director
CI Solutions LLC
During Business hours, Eastern Time Zone 1-859-442-8590

Notice

The information given and the recommendations made herein apply to our product(s) alone and not in combination with any other product(s). Such information and recommendations are based on our research and on data from other reliable sources and are believed to be accurate but no guaranty of their accuracy is made. In every case we urge and recommend that purchasers, before using any product, make their own tests to verify this data under their operating conditions and to determine to their own satisfaction whether the product is suitable for their particular purposes.

THE PRODUCT(S) DISCUSSED HEREIN ARE SOLD WITHOUT ANY WARRANTY AS TO MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER WARRANTY, EXPRESSED OR IMPLIED.

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1157 Industrial Road • Cold Spring, KY 41076 • USA
Tel +1 859 442 8590 • Fax +1 859 781 8280

CL Solutions' products, CL-Out and Petrox consist of multiple strains of patented aerobic microbes known for their ability to degrade a wide range of chlorinated solvents and petroleum hydrocarbons. Each batch contains billions of "Hungry Bacteria®" whose only purpose is to degrade harmful environmental contaminants into harmless byproducts such as carbon dioxide and water.

FOR MORE INFORMATION

- [Request Further Product Info](#)
- [Visit our Website](#)
- [Send us an Email](#)
- [Read Selected Articles](#)

PRODUCT LINE

- [CL-Out™ \(Rapid Bioremediation of Chlorinated Contaminants\)](#)
- [Petrox™ \(Rapid Bioremediation of Petroleum Contaminants\)](#)
- [Petrox-EC \(Biological Surface Treatment for Petroleum Hydrocarbons\)](#)

COMPANY INFORMATION

**AEROBIC BIOREMEDIATION OF
PETROLEUM HYDROCARBONS AND
CHLORINATED SOLVENTS
IN SOIL AND GROUNDWATER**



As a leader in the field of aerobic bioremediation, CL Solutions rapidly and affordably bioremediates soil and groundwater contaminated with hydrocarbons and chlorinated solvents. The company's products, CL-Out and Petrox™, contain highly-concentrated solutions of live **patented** microscopic organisms (microbes) that occur naturally in the earth's ecosystem.

Extracted from a once-contaminated site and isolated under controlled laboratory conditions, these "hungry bacteria®" have only one purpose in life: to seek and destroy contamination at its source, and then quickly convert it into harmless, naturally recyclable by-products.

Complete remediation often occurs in a matter of weeks or months.



several years or more for other methods, giving users the combine benefit of fast site closure and remarkable cost savings. Bioremediation with our products is effective as a stand-alone technology or may to augment an existing treatment method.

About CL Solutions, LLC

Headquartered in Cold Spring, Kentucky, CL Solutions is proud to be the exclusive distributor of patented microorganisms produced by Osprey Biotechnics of Sarasota, Florida. Our bioremediation products, CL-Out™ and Petrox™, have been used throughout North America since 1997, and are field-proven to successfully close sites in a shorter period of time than other remediation technologies currently available – a fact that helps property owners who use CL Solutions realize substantial cost savings.

Equally effective when used as a standalone remediation solution or to augment existing treatment programs, each product stands up to rigorous product safety and quality standards. And, because of their faster than average cleanup rates, all CL Solutions products remain remarkably affordable, making property redevelopment feasible for any contaminated site, industrial or commercial.



Product Line

Used as a sole treatment technology or to augment an existing treatment system, CL-Solutions' of aerobic bioremediation products work faster, work better, and cost significantly less than other hazardous waste cleanup products or processes.

CL-OUT 
Rapid Bioremediation for Chlorinated Contaminants

PETROX 
Rapid Bioremediation for Petroleum Contaminants

PETROX-EC 
Biological Surface Treatment

[PCE/TCE Co-metabolic Pathway Chart](#)

[Detailed Contaminant Listing Guide](#)



For use in Gas Stations, Vehicle Repair Facilities, Machine Shops, and wherever oil and grease may accumulate

CL-OUT

Rapid Bioremediation for Chlorinated Contaminants

CL-Out™ delivers active, rapid bioremediation of environmental contamination caused by chlorinated solvents.

An All-Natural Product

It contains a highly-concentrated solution of live, **patented** strains of lyophilized (freeze-dried) *Pseudomonas* organisms that occur naturally in the earth's ecosystem. These cultures are free of pathogens and there is no artificial mutation or genetic engineering involved. Extracted from a contaminated site and isolated under controlled laboratory conditions, these "hungry bacteria®" only one purpose in life: to seek and destroy contaminated waste at its source, and then quickly it into harmless, naturally recyclable by-products.

From Brown To Green Faster

CL-Out has been used throughout the USA and Canada, with example contamination concentration reduced from greater than 10,000 ppb to less than 5 ppb. Site closure often occurs in a matter of months versus several years or more for other methods, giving users the combined benefit of closure and remarkable cost savings.

Applications

- Commonly used in the dry cleaning, metals manufacturing, printing, and electronics manufacturing industries
- Designed for standalone application or for augmentation of existing treatments, including vapor stripping, sparging, excavation, and dual-phase extractions technologies
- Effectively remediates Carbon Tetrachloride, Chlorodane, Chlorobenzene, Dichlorobenzene, Dichloroethane (1,1-) & (1,2-), Dichloroethylene (1,2-DCE), Dichloropropane (1,2-), Dinonylphthalate, Methylene Chloride, MTBE (Methyl Tertiary Butyl Ether), Tetrachlorethar (1,1,2,2-) (acetylene tetrachloride), Tetrachloroethylene (PCE, PERC, perchloroethylene, et tetrachloride), Trichloroethane (1,1,1-TCA) and (1,1,2-), Trichloroethylene (TCE), Vinyl Chloride

Each CL-Out product batch is manufactured under sterile conditions, and subjected to stringent control protocols before release for shipment. Specifically designed for seeding ex situ or in situ bioremediation project, it is available as a ready-to-use concentrated liquid, as a freeze-dried powder pre-mixed by the drum. CL-Out can be used as a highly effective stand-alone decontamination solution for new sites, or as a powerful augmentation to speed the remediation of existing sites.

Environmental Conditions for Effective Treatment

Parameter	Effective Range	Optimum Range
PH	5.0-9.0	6.5-7.5
Temperature	55-95°F	65-75°F
Salinity	0-5%	<5%
Dissolved Oxygen	>1.0ppm	1-8ppm

VIDEO DEMONSTRATION

With CL-Out, remediation of contaminated sites is fast and simple, also making its use remarkably cost-effective. To provide a firsthand look, we've put our step-by-step instructions into motion with a short video you can watch right now on your computer. [See for yourself just how easy it can be to turn your brownfields into green! \(click here now\)](#)

PETROX

Rapid Bioremediation for Petroleum Contaminants

Petrox™ delivers active, rapid bioremediation of environmental contamination caused by industrial commercial hydrocarbons.

An All-Natural Product

It contains a highly-concentrated solution of live, patented strains of lyophilized (freeze-dried) *Pseudomonas* organisms that occur naturally in the earth's ecosystem. These cultures are free of pathogens and there is no artificial mutation or genetic engineering involved. Extracted from a contaminated site and isolated under controlled laboratory conditions, these "hungry bacteria®" only one purpose in life: to seek and destroy petroleum hydrocarbons, organic solvents, and semi-volatile hydrocarbons at their source, and then quickly convert them into harmless, naturally occurring by-products.

From Brown To Green Faster

Site closure often occurs in a matter of weeks or months versus several years or more for other methods, giving users the combined benefit of fast site closure and remarkable cost savings.

Standard Blends

Available in three standard blends or custom formulated for specific needs, Petrox can be used as a highly effective stand-alone decontamination solution for new sites, or as a powerful augmentation to speed the remediation of existing sites.

Petrox 1™- BTEX compounds (Benzene, Toluene, Ethylbenzene, Xylene), Benzene, Dichlorotoluene (2,5-), Diethylphthalate (common PVC plasticizer), Ethyl Benzene, Fuels (gasoline, diesel and heating oils), Methyl Ethyl Ketone (MEK, 2-butanone), Methylene Chloride, Mineral spirits, Naphthalene (Naphthalin, Naphthene, tar camphor), Stoddard solvents, Toluene (Methylbenzene), Xylene (Dimethylbenzene, [ortho, meta, para])

Petrox 2™- Citrus Industry by-products, D-Limonene (Including citrus-based cleaning compounds), Isoprenoids (A class of organic compounds produced by plants), Terpene compounds (Natural hydrocarbons produced by plants), Terpene-based solvents

Petrox 3™- Anthracene, Chlorotoluene (M-), Chlorotoluene (O-), Chlorotoluene (P-), Chrysene, (ortho, methyl and paramethylphenols), Creosote (phenol mixture), Fluorene, Oils and Greases (and petroleum), Pesticides, including 1,2-D, 2,4-D, Aldrin, Endrin, Pentachlorophenol (PCP, pencyl Santophen 20), Phenanthrene, Phenol (Carbolic acid, phenylhydroxide, hydroxybenzene)

Applications

- Commonly used at fuel terminals and gas stations, in the metals and chemicals industries, production, railroads, manufactured gas plants, and wood treatment facilities
- Designed for standalone application or for augmentation of existing treatments, including vapor stripping, sparging, excavation, and dual-phase extractions technologies

Each Petrox product batch is manufactured under sterile conditions, and subjected to stringent quality control protocols before release for shipment. Available as a freeze-dried powder and hydrated or for the highest possible microbial activity, each culture is provided with unique nutrient/growth formulation to maximize viable cell count.

Environmental Conditions for Effective Treatment

Parameter	Effective Range	Optimum Range
PH	5.0-9.0	6.5-7.5
Temperature	55-95°F	65-75°F
Salinity	0-5%	<5%
Dissolved Oxygen	>1.0ppm	1-8ppm

Petrox: Demonstrated Remediation Rates

Contaminant	Initial Concentration (ppm)	Final Concentration (ppm)	Test Period (hours)	Percent Reduction	Degradation (mg/L/hr ± CFU/n)
Fuel Oil in Water	2,000	1,400	40	30%	15
Fuel Oil in Sand	2,000	1,400	240	30%	2.5
Ethyl Benzene	3	0	168	100%	0.02
Xylene	3.6	0.4	168	89%	0.02
Toluene	99	15	168	85%	0.5
Methyl Ethyl Ketone	21	4	168	81%	0.1
Phenol	90	0	48	100%	1.9
Methylene	15	0	168	100%	0.09

Chloride					
Pentachlorophenol	50	32	84	35%	0.21
Diethylphthalate	100	70	120	30%	0.25

PETROX-EC

Biological Surface Treatment

**For use in Gas Stations, Vehicle Repair Facilities,
Machine Shops, and wherever oil and grease
may accumulate**

Formulated in
Partnership with



Product Features

- Treats surfaces soiled with gasoline, oil and grease
- Degrades minor petroleum hydrocarbon spills
- Eliminates slippery build-up on hard surfaces
- Remediates chemical contamination harmful to the environment
- 100% biodegradable bacterial cultures and mild surfactant
- Safe — PH Neutral
- Non-corrosive — will not etch or degrade concrete
- Economical — 1 to 4 ounces per gallon of water



Technical Resources

Product Profiles

CL-Out™

▼ DOWNLOAD ADOBE PDF

Petrox™

▼ DOWNLOAD ADOBE PDF

Material Safety Data Sheet

▼ DOWNLOAD ADOBE PDF

▼ DOWNLOAD ADOBE PDF

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Microbial Analysis Request Form
[NEW, PDF*]**Field Treatment Studies**

Products from CL Solutions contains blends of patented microbial strains isolated from contaminating soils where these naturally occurring organisms had adapted to the presence of contaminants and in fact, developed the ability to directly metabolize or co-metabolize the contaminants. Laboratory and field studies have shown that these metabolic processes will break contaminants down into harmless byproducts.

Bioremediation with CL Solutions can significantly improve soil and ground water quality within a period of time, and prove to be effective in both high contaminant concentrations and lower concentrations. Site remediation occurs in a timely and cost-effective manner, making it possible to rapidly restore the environmental conditions and economic value to a wide range of contaminated industrial or commercial properties.

The following links provide descriptions of recent field tests of CL-Out and Petrox, and the positive results observed.

[Chemical Plant in Toronto, Canada](#)

[Dry Cleaners in Kentucky, USA](#)

[Printing Facility in Indiana, USA](#)

[Self-Service Dry Cleaners in Ohio, USA](#)

[Cost Comparison of CL-Out vs. SVE/Air Sparge](#)

[Printing Facility in Tennessee, USA](#)

[Request further Product Information](#)

[Back to Soil & Groundwater Remediation Equipment Index](#)

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ATTACHMENT D

CLEARWATER GROUP

Soil Borehole Drilling, Monitoring Well Installation and Development, and Groundwater Sampling Field Procedures

Drilling and Soil Sampling

Permits, Site Safety Plan, Utility Clearance

Clearwater Group obtains all the required permits, unless otherwise contractually directed. Clearwater prepares a site specific Site Safety Plan detailing site hazards, site safety and control, decontamination procedures, and emergency response procedures to be employed throughout the defined phase of work. At least 48 hours prior to drilling, Underground Service Alert (USA) or an equivalent agency is notified of the planned work. Clearwater, attempts to locate all underground and above ground utilities by site inspection (in conjunction with its subcontractors and knowledgeable site managers, if available), and review of site as-built drawings. Clearwater may employ a private, professional utility locator to refine the site utility inspection.

Drilling Equipment

All soil borings are drilled using a truck-mounted hollow-stem auger drill rig, unless site conditions warrant a different drilling method. Subsurface conditions permitting, the first five feet of each boring is advanced using a hand-auger or post-hole digger. All drilling equipment is inspected daily and maintained in safe working condition by the operator. All down-hole drilling equipment is steam cleaned prior to arriving on site. Working components of the drill rig near the borehole, as well as augers and drill rods are thoroughly steam cleaned between each boring location. All CLEARWATER drilling and sampling methods are consistent with ASTM Method D-1452-80, and local, state and federal regulations.

Soil Sampling and Lithologic Description

Whenever possible, the first Clearwater boring to be drilled at a site is continuously cored to obtain a complete lithologic description. Otherwise, soil samples are typically collected every 5 feet to the total depth explored, using brass tubes fitted in a California-modified split spoon sampler. If copper or zinc contamination is the subject of the investigation, stainless steel liners are used instead of brass. Additional soil samples may be collected based upon significant changes in lithology or in areas of obvious soil contamination. During soil sample collection, the split spoon sampler is driven 18 to 24 inches past the lead auger by a 140-pound hammer falling a minimum of 30 inches. The number of blows necessary to drive the sampler and the amount of soil recovered is recorded on the Field Exploratory Soil Boring Log. The soil sampler and liners are cleaned with an Alconox® solution and rinsed with tap water prior to each sampling event. New liners are used whenever a soil sample may be retained for laboratory analysis.

Soil samples selected for laboratory analysis are sealed on both ends with teflon tape and plastic end caps. The samples are labeled, documented on a chain-of-custody form and placed in a cooler for transport to a state certified analytical laboratory. Soil contained in remaining liners is removed for lithologic descriptions (according to the Unified Soil Classification System). Additional soil is screened for organic vapors by placing approximately 30 grams of soil in a sealed plastic bag or a glass jar sealed with aluminum foil. The bag or jar is left undisturbed for approximately 15 minutes, in the sun if possible. The head space in the bag is accessed in a manner to minimize entry of outside air, and is tested for total organic vapor using a calibrated organic vapor meter (OVM). The results of the field screening are noted with the lithologic descriptions on the Field Exploratory Soil Boring Log.

On encountering an impermeable (clayey) layer three feet or more in thickness below a saturated permeable layer, where the impermeable layer is considered to be a possible confining layer for an underlying aquifer, drilling is halted until a decision to proceed is obtained from the project manager. This process minimizes the chance of introducing contamination to an underlying, clean aquifer.

Soil Waste Management

Soil cuttings are stockpiled on and covered with plastic sheeting to control runoff, or contained in 55-gallon D.O.T.-approved drums on site. Waste soil is sampled to chemically profile it for disposable, and hauled by a

licensed waste hauler to an appropriate landfill. All waste stored on site is properly labeled at the time of production.

Soil Boring Abandonment

Soil borings which are not to be converted into monitoring wells are sealed to the ground surface using neat cement or sand-cement slurry in accordance with federal, state and local regulations. Native soil may be used to fill the top two to three feet for cosmetic purposes, as permitted.

Monitoring Well Installation

Well Casing, Screen and Filter Pack Construction

All well construction is performed in accordance with Department of Water Resources "California Well Standards" and all requirements of local oversight agencies. Soil borings to be converted into single-cased monitoring wells are a minimum of eight inches in diameter for 2-inch diameter wells and a minimum of ten inches in diameter for 4-inch diameter wells. Monitoring wells are constructed with schedule 40, threaded, polyvinyl chloride (PVC) casing unless site geochemistry or contamination necessitates an alternative material. The wells are constructed with factory-slotted screen and threaded end caps.

The screened interval is placed such that it extends approximately ten feet into the water bearing zone, and at least five feet above the expected maximum water level. The screened interval may extend less than five feet above the maximum water level, only to prevent intersection of the screened interval with the top of the confining layer of a confined aquifer, or where the water table is too shallow to allow this construction.

A graded sand filter pack is placed in the annular space across the screened interval and extended approximately one to two feet above the screen, as site conditions permit, so as to prevent extension of the sand pack into an overlying water-bearing unit. The well screen slot size is the maximum size capable of retaining 90% of the filter pack. Typically, 0.010-inch screen is used where the formation is predominantly clay and/or silt or poorly-graded fine sand. 0.020-inch screen is used where the formation is predominantly well-graded or medium to coarse sand and/or gravel.

The filter pack grade (mean grain size) is selected according to native sediment type as follows: a) for poorly graded fine sand or silt/clay - 4 times the 70% retained grain size of the formation b) for medium to coarse sand, gravel or well graded sediments - 6 times the 70% retained grain size. Since results of particle size analysis are not always available, Clearwater often selects screen size and filter pack on the basis of general site stratigraphy, and specifically the finest significantly thick layer of sediment to be screened. Commonly selected grades are Lone Star® 3, 2/12 or 2/16 (or equivalent) with 0.020-inch slotted screen and Lone Star® 1/20 with 0.010-inch slotted screen.

Well Seal and Completion

A minimum two foot seal of bentonite is placed above the sand pack. The bentonite seal is hydrated by either formation water or potable water. Neat cement or a cement/bentonite grout mixture seals the remaining annular space to the surface. If bentonite is used in the grout mixture, it does not exceed 5% by weight. The grout is placed using a tremie pipe, if the top of the bentonite is more than 20 feet below grade, or if water is present in the boring above the bentonite seal. A watertight locking cap and protective traffic-rated vault box is installed on top of each well. Well construction details are presented on the Field Exploratory Soil Boring Log. Following completion of a well, Clearwater completes and submits, or ensures that the driller has sufficient information to complete and submit, the state-required Well Completion Report or equivalent document.

Well Development

All newly installed wells are developed prior to sampling to remove fine grained sediments from the well and stabilize the filter pack and the disturbed aquifer materials. Development takes place prior to or at least 24 hours after setting the seal on the well, unless otherwise directed by a local oversight agency. Well development consists of surging with a surge block and removing water from the well with either a pump or bailer, until the well is free of sediment, or until at least 10 well casing volumes have been removed. Depth to bottom is measured to determine casing volume. If the well is sampled immediately following development, temperature, pH, specific

conductance and turbidity (qualitative) are monitored during well development (see section "Groundwater Sampling"). All development equipment is cleaned prior to use and between wells with an Alconox® solution, then rinsed in potable water. All data collected during development are recorded on the Well Development Data Sheet and, if necessary, the Purging Data Sheet.

Well Surveying

All well elevations are surveyed at the north side of the top of casing to the nearest ± 0.01 foot. The exact survey point (at the center of the survey rod or, if the casing stub is uneven, the point of contact between casing and rod) is clearly marked and maintained on the casing rim. Elevations are referenced either to mean sea level or to a project datum. A project datum is typically chosen so as to minimize the possibility of its later disturbance. For instance, fire hydrants are commonly selected. Where required, the wells are surveyed by a licensed land surveyor, relative to mean sea level.

Groundwater Sampling

Groundwater Monitoring

Prior to beginning, a decontamination area is established. Decontamination procedures consist of scrubbing downhole equipment in an Alconox® solution wash (wash solution is pumped through any purging pumps used), and rinsing in a first rinse of potable water and a second rinse of potable water or deionized water if the latter is required. Any non-dedicated down hole equipment is decontaminated prior to use.

Prior to purging and sampling a well, the static water level is measured to the nearest 0.01 feet with an electronic water sounder. Depth to bottom is typically measured once per year, at the request of the project manager, and during Clearwater's first visit to a site. If historical analytical data are not available, with which to establish a reliable order of increasing well contamination, the water sounder and tape will be decontaminated between each well. If floating separate-phase hydrocarbons (SPH) are suspected or observed, SPH is collected using a clear, open-ended product bailer, and the thickness is measured to the nearest 0.01 feet in the bailer. SPH may alternatively be measured with an electronic interface probe. Any monitoring well containing a measurable thickness of SPH before or during purging is not additionally purged and no sample is collected from that well. Wells containing a hydrocarbon sheen are sampled unless otherwise specified by the project manager. Field observations such as well integrity as well as water level measurements and floating product thicknesses are noted on the Gauging Data/Purge Calculations form.

Well Purging

Each monitoring well to be sampled is purged using either a PVC bailer or a submersible pump. Physical parameters (pH, temperature and conductivity) of the purge water are monitored during purging activities to assess if the water sample collected is representative of the aquifer. If required, parameters such as dissolved oxygen, turbidity, salinity etc. are also measured. Samples are considered representative if parameter stability is achieved. Stability is defined as a change of less than 0.25 pH units, less than 10% change in conductivity in micro mhos, and less than 1.0 degree centigrade (1.8 degrees Fahrenheit) change in temperature. Parameters are measured in a discreet sample decanted from the bailer separately from the rest of the purge water. Parameters are measured at least four times during purging; initially, and at volume intervals of one well volume. Purging continues until three well casing volumes have been removed or until the well completely dewater. Wells which dewater or demonstrate a slow recharge, may be sampled after fewer than three well volumes have been removed. Well purging information is recorded on the Purge Data sheet. All meters used to measure parameters are calibrated daily. Investigation derived wastes (purge and rinsewater) is handled in one of three ways: 1) Purge and rinsewater is sealed, labeled, and stored on site in D.O.T.-approved 55-gallon drums. After being chemically profiled, the water is removed to an appropriate disposal facility. 2) Purge and rinsewater is collected into a 250-gallon portable holding tank and transported to the Clearwater equipment yard in Point Richmond, CA. At the yard the investigation derived waste is then transferred to 55-gallon drums pending disposal at an appropriate disposal facility, or 3) Purge and rinsewater is collected in a 250-gallon portable holding tank and transported to the appropriate disposal facility. The applicable method will be indicated in the field log sheets and the corresponding technical report.

Groundwater Sample Collection

Groundwater samples are collected immediately after purging or, if purging rate exceeds well recharge rate, when the well has recharged to at least 80% of its static water level. If recharge is extremely slow, the well is allowed to recharge for at least two hours, if practicable, or until sufficient volume has accumulated for sampling. The well is sampled within 24 hours of purging or repurged. Samples are collected using polyethylene bailers, either disposable or dedicated to the well. Samples being analyzed for compounds most sensitive to volatilization are

collected first. Water samples are placed in appropriate laboratory-supplied containers, labeled, documented on a chain of custody form and placed on ice in a cooler for transport to a state-certified analytical laboratory. Analytical detection limits match or surpass standards required by relevant local or regional guidelines.

Quality Assurance Procedures

To prevent contamination of the samples, Clearwater personnel adhere to the following procedures in the field:

- A new, clean pair of latex gloves are put on prior to sampling each well.
- Wells are gauged, purged and groundwater samples are collected in the expected order of increasing degree of contamination based on historical analytical results.
- All purging equipment will be thoroughly decontaminated between each well, using the procedures previously described at the beginning of this section.
- During sample collection for volatile organic analysis, the amount of air passing through the sample is minimized. This helps prevent the air from stripping the volatiles from the water. Sample bottles are filled by slowly running the sample down the side of the bottle until there is a convex meniscus over the mouth of the bottle. The lid is carefully screwed onto the bottle such that no air bubbles are present within the bottle. If a bubble is present, the cap is removed and additional water is added to the sample container. After resealing the sample container, if bubbles still are present inside, the sample container is discarded and the procedure is repeated with a new container.

Laboratory and field handling procedures may be monitored, if required by the client or regulators, by including quality control (QC) samples for analysis with the groundwater samples. Examples of different types of QC samples are as follows:

- Trip blanks are prepared at the analytical laboratory by laboratory personnel to check field handling procedures. Trip blanks are transported to the project site in the same manner as the laboratory-supplied sample containers to be filled. They are not opened, and are returned to the laboratory with the samples collected. Trip blanks are analyzed for purgable organic compounds.
- Equipment blanks are prepared in the field to determine if decontamination of field sampling equipment has been effective. The sampling equipment used to collect the groundwater samples is rinsed with distilled water which is then decanted into laboratory-supplied containers. The equipment blanks are transported to the laboratory, and are analyzed for the same chemical constituents as the samples collected at the site.
- Duplicates are collected at the same time that the standard groundwater samples are being collected and are analyzed for the same compounds in order to check the reproducibility of laboratory data. They are typically only collected from one well per sampling event. The duplicate is assigned an identification number that will not associate it with the source well.

Generally, trip blanks and field blanks check field handling and transportation procedures. Duplicates check laboratory procedures. The configuration of QC samples is determined by Clearwater depending on site conditions and regulatory requirements.

5035SCTM Soil Core Sampler and Procedures

The purpose of the EPA Method 5035 is to reduce volatilization of soil samples prior to laboratory analyses. Other methods, notably ASTM (D4547-98) have also been developed to minimize losses in volatile organic compounds (VOC) and semi-volatile organic compound (SVOC) during soil sample collection and storage. Soil piles or even soil tubes from trenches or borings can use EPA Method 5035.

The United States Environmental Protection Agency (USEPA) developed EPA Method 5035, Closed-System Purge-and-Trap Extraction for Volatile Organics in Soil and Waste Samples in June 1997 in SW-846, Test Methods for Evaluating Solid Waste, Physical / Chemical Methods, Update III (Method 5035). In July 2002, USEPA updated the Method within SW-846 as Method 5035A. (USEPA, 2003). The 5035SCTM Sampler is a zero-headspace, multi-functional sampling device (MFSD) designed to meet the EPA Method 5035 and Florida Department of Environmental Protection FS 3000 approved methods. The MFSD act as both the coring tool and airtight storage container (USEPA, 2003).

5035SCTM SAMPLER

The 5035SCTM Sampler is a pre-cleaned syringe subcore sampler and storage device. The USEPA (2003) approves the use of the disposable plastic syringes that have been converted into subcoring devices. The syringe "needle end" has been cut off neatly, creating a blunt, even coring end. The 5035SCTM Sampler was designed to meet the description of the EPA, by being disposable, inexpensive, and to have zero headspace. The 5035SCTM Sampler requires no in-field weighing and no preservative. The 5035SCTM Sampler features a patented "plunger stop" sleeve which prevents the plunger from exiting the open end of the syringe. Each 5035SCTM Sampler comes with an airtight plastic cap. The disposable samplers may be used once per sampling location and should not be reused.

APPROVAL FOR USE

The California Regional Water Quality Control Board, Region 1 (North Coast) has approved the 5035SCTM Sampler for fuel related sites as both a coring and as a transportation device. The Department of Toxic Substances Control (DTSC) and the U.S. EPA (Region 9) have approved the 5035SCTM Sampler for use for the soil coring and preservation in the field at DTSC and EPA sites, respectively. Using the 5035SCTM Sampler as a transportation device for DTSC or EPA sites has not yet been approved.

COLLECTING THE SOIL

All sampling activities are to be performed using sanitary, industrial grade, chemically resistant gloves. The soil sample is collected using the 5035SCTM Sampler by removing the pre-cleaned plastic cap. The plunger is shipped in the forward position. Holding the wingtips on either side of the sampler body, the 5035SCTM Sampler is pushed into the soil to be sampled. The 4.5 to 5.5 grams of dry to semi-dry soils will pack tightly into the

body of the 5035SC™ Sampler, pushing the plunger back to its rear position. The patented plunger stop of the 5035SC™ Sampler sleeve prevents the plunger from exiting the body of the sampler. The filled soil sampler containing 5 grams of soil is then removed from the soil and the airtight plastic cap is pushed over the open end of the sampler.

The soil sample is then either placed into specially prepared 40 ml glass VOAs for chemical preservation (see below) or placed into a hermetically sealed reclosable polyethylene-shipping bag. Once the 5035SC™ Sampler is placed in the sampler-shipping bag and is tagged with the waterproof label, it is ready to be placed into the cooler with the dry ice to be kept at $<-7^{\circ}$ C. Chain-of-custody procedures are used to accompany the samples to the laboratory.

SCREENING OF SOIL SAMPLES

In order to provide valuable soil analysis data, lithologic variations and heterogeneity, both vertically and laterally must be well characterized and understood so that representative soil samples are collected. Soil samples should be screened in the field with a meter that measures organic vapors, such as a photoionization detector (PID). Field screening gives a rough estimate of VOC concentration and other factors such as visual staining, soil discoloration and professional judgment should be used to pick the samples for EPA Method 5035.

FIELD PRESERVATION METHODS

There are several field preservation methods using a variety of procedures and chemicals. The preservation concepts are described below. For field preservation methods using chemicals, the 5035SC™ Sampler is then removed from the syringe and extruded into the glass VOA vial using the syringe's plunger if other field preservation methods are to be used. Please refer to USEPA, 2003 for more detailed preservation descriptions.

U.S. EPA and the California DTSC have approved the 5035SC™ Sampler for use as a soil-coring device. Field preservation methods are to be used with the 5035SC™ Sampler for EPA and DTSC sites. Many laboratories will supply consultants with the glass 40 ml VOAs with the preservation chemicals, as described below.

CHEMICAL PRESERVATION FOR LOW LEVEL ANALYSIS

Low Level Analysis uses a hermetically sealed sampling container, such as the 5035SC™ Sampler, and analysis of the sample in the laboratory by a closed-system purge-and-trap process. The Low Level Analysis method uses a direct purging of the VOCs from the liquid inserted into the soil sample in the field. The liquid can be either sodium bisulfate or reagent water, the former acts as both preservative and extractant medium, while the water acts only as an extractant medium. No sample dilution is involved, giving detection limits of approximately 0.5 µg/kg.

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The 5035SC™ Sampler has been approved for use as a coring device by U.S. EPA and the California DTSC. Field preservation methods are to be used with the 5035SC™ Sampler for EPA and DTSC sites.

CHEMICAL PRESERVATION FOR HIGH LEVEL ANALYSIS

The procedures for High Level Analysis use the same procedures outlined above, except methanol is the liquid used for both preservative and extractant medium. The samples are diluted with methanol yielding detection limits of greater than 200 µg/kg.

FIELD PRESERVATION BY FREEZING

The 5035SC™ Sampler can be used with field freezing with dry ice as the preservation method. Freezing the sample in its storage device immediately after collection preserves VOC concentrations in all samples matrices (including biologically active soils that would tend to degrade BTEX compounds) and for both types of VOC analytes for up to 14 days of storage. In one study, sample integrity was maintained with less than a 5% loss of analyte concentrations even after a 14-day holding time. Freezing can be initiated in the field through the use of dry ice in well-insulated coolers. Alternatively, bags of water ice mixed with table salt may be used to achieve cooler temperatures between -12 and -4°C (Hewitt, 1999). Dry ice is recommended as being the easiest method of field freezing and preservation. The disadvantage of using ice (4°C +/- 2°C) is that the samples would be required to be analyzed within 48 hours in the laboratory, instead of the 7 days for dry ice freezing.

After collecting the 4.5 to 5.5 grams of soil samples in the pre-cleaned 5035SC™ Sampler, the sampler is sealed with an airtight inert plastic cap. The 5035SC™ Sampler is then placed into a hermetically-sealed reclosable polyethylene shipping bag, with a waterproof label with date, time, sampler's name, sample number, site location, compounds of interest, chemical preservation techniques (if any), and laboratory equipment specifications or laboratory methods.

The 5035SC Samplers are then placed in a cooler with dry ice to ensure freezing of the 5035SC™ Samplers. There must be adequate dry ice to cool the samples to <-7° C and that the temperature is maintained in the cooler during transport to the laboratory. The samples are labeled and shipped under chain-of-custody procedures to the state-approved laboratory for the requested analysis. The 5035SC™ Samplers should not be frozen below -20° C. A temperature blank should be included with the samples so that the laboratory can verify the temperature upon receipt and the arrival temperature of the samples should be noted on the chain-of-custody forms. Because the entire sampling device is to be submitted to the laboratory, a visual inspection of the seals is required to be noted on the chain-of-custody by the receiving person at the laboratory to verify that the 5035SC™ Sampler is intact and sample volatilization has not occurred.

LABORATORY HOLD TIME

The 5035SCTM Samplers preserved with dry ice the samples can be held at $<-7^{\circ}\text{C}$ for up to seven days prior to analysis from the sample collection date, providing the laboratory places the samples in a refrigerated environment or uses a chemical preservation method.

TEMPERATURE BLANK

Method 5035 requires and many laboratories expect three 5035SCTM Samplers for each soil sampling point. For example, if a soil boring has 2 samples, one at 5 feet and one at 10 feet below ground surface, three 5035SCTM Samplers are needed for each soil sampling point, with a total of six 5035SCTM Samplers required for the two sampling points. On the receiving end, an infrared thermometer should be used to measure the temperature blank when the samples arrive at the laboratory.

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PHOTOS SHOWING THE 5035SC™ SAMPLER

- 1) The soil sample is collected using the 5035SC™ Sampler by removing the pre-cleaned plastic cap. The plunger will be in the forward position.
- 2) Holding the wingtips on either side of the sampler body, push the 5035SC™ Sampler into the soil to be sampled. The soil will pack tightly into the body of the 5035SC™ Sampler, pushing the plunger back to its rear position. The patented plunger stop of the 5035SC™ Sampler sleeve prevents the plunger from exiting the body of the sampler.
- 3) Remove the filled soil sampler from the soil and press the airtight plastic cap over the open end of the sampler. The soil sample is placed into a hermetically sealed reclosable polyethylene-shipping bag.
- 4) Once the 5035SC™ Sampler is placed in the sampler shipping bag and is tagged with the waterproof label, it is ready to be placed into the cooler with the dry ice to be kept at $<-7^{\circ}\text{C}$ (7-days) or ice cooled to 4°C (48-hour preservation).

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